PB-240 051

RADIOLOGICAL HEALTH DATA. VOLUME 6, NUMBERS 4-6, APRIL-JUNE 1965

Public Health Service
Washington, D. C.

June 1965

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BIBLIOGRAPHIC DATA SHEET

1. Report No. RHD 6 (4-6)

2.

PB 240 051

4. Title and Subtitle
Radiological Health Data
Volume 6 Nos 4-6

5. Report Date Apr-June 1965

6.

7. Author(s) None

8. Performing Organization Rept. No.

9. Performing Organization Name and Address
U.S. Department of Health, Education, and Welfare
Public Health Service
Washington, D. C. 20201

10. Project/Task/Work Unit No.

11. Contract/Grant No.

12. Sponsoring Organization Name and Address
U.S. Environmental Protection Agency
Office of Radiation Programs
401 M St., S. W.
Washington, D. C. 20460

13. Type of Report & Period Covered Final: Apr-June 1965

14.

15. Supplementary Notes

16. Abstracts

Data and interpretation of data on radiation exposure to humans and on radioactivity in milk, water, air, and other environmental media are presented in 23 volumes. For prices of individual issues, see below! ←

17. Key Words and Document Analysis. 17a. Descriptors

Radiation
Radioactivity
Air
Water
Milk
Food
Human

17b. Identifiers/Open-Ended Terms

17c. COSATI Field/Group

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US Department of Commerce
Springfield, VA. 22151

PRICES SUBJECT TO CHANGE

18. Availability Statement
Release unlimited

1

19. Security Class (This Report) UNCLASSIFIED

20. Security Class (This Page) UNCLASSIFIED

21. No. of Pages 159

22. Price PC/MF 6.25/2.25

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VOLUME 6, NUMBER 4
APRIL 1965

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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service • Division of Radiological Health

Synopses of contributed articles are presented below in reference card format for the reader's convenience.

DETECTION OF FALLOUT FROM CHINESE NUCLEAR TEST OF OCTOBER 16, 1964, BY THE NATIONAL AIR SAMPLING NETWORK. *Branson, B., E. Tabor, G. Holsworth, S. Gold, J. Hardin,* and *B. Kahn* (Division of Radiological Health and Division of Air Pollution) *Radiological Health Data, Vol. 6, April 1965,* pp. 188–192.

Analyses of NASN air filters following the October 16, 1964, Chinese nuclear test showed that most areas of the United States recorded at least trace amounts of recently formed fission products on airborne particles. These fallout concentrations are considered with reference to the estimated high-level trajectory of the explosion debris. The time lag between passage of the upper tropospheric cloud and the settling of debris to the surface is discussed in terms of the atmospheric processes of vertical mixing and precipitation.

COMPARISON OF RADIONUCLIDE CONCENTRATIONS IN MILK FROM DISTRIBUTORS SERVING THE CITY OF BOSTON. *Baratta, E. J., M. A. Wall,* and *H. Mazer* (Division of Radiological Health and Boston City Health Department) *Radiological Health Data, Vol. 6, April 1965,* pp. 212–216.

The radionuclide content of fluid milk samples from Boston distributors is compared with that of the Public Health Service Pasteurized Milk Network station sample, and the validity of the sampling procedures used is investigated. Analyses of weighted and unweighted, monthly and yearly average strontium-90, cesium-137, and strontium-89 levels indicated that, (1) the Network sample offered a good estimate of radionuclide content of milk from individual commercial distributors, (2) the compositing procedure used was adequate under the circumstances, and (3) a sampling program which accounted for approximately 80 percent of all milk supplied in the area was adequate for preparing the composite sample.

CESUM-137 BURDENS IN MAN, JULY 1963 THROUGH AUGUST 1964. *Leitnaker, F. C., R. C. Reba,* and *K. T. Woodward* (Walter Reed Army Institute of Research) *Radiological Health Data, Vol. 6, April 1965,* pp. 227–229.

Cesium-137 whole body burdens of 690 subjects determined at the Walter Reed Army Institute of Research (WRAIR) from July 1963 through August 1964 are reported. Ninety-five percent confidence limits of about ±1.2 nc are achieved by a 200-second count in the WRAIR 4π liquid scintillation counter. When obviously contaminated subjects are eliminated, levels of gamma activity of handlers of gamma-emitters do not differ significantly from the general population.

The Cs^{137}/K ratio for the period under study was found to be log-normally distributed when children were deleted. A maximum level of about 100 pc Cs^{137}/g K was reached in the late spring of 1964. Differences in levels from different parts of the U.S. were statistically significant but the levels in Americans returning after European residence were slightly higher.

STABLE ELEMENTS AND RADIONUCLIDES IN HUMAN MILK. *Straub, Conrad P.* and *Gopala K. Murthy* (Robert A. Taft Sanitary Engineering Center) *Radiological Health Data, Vol. 6, April 1965,* pp. 230–231.

Calcium, potassium, strontium-90, and cesium-137 concentrations in human milk samples from the Denver and Chicago areas are compared. Values obtained are in agreement, with the exception of potassium. This discrepancy is believed to be due to the nature of the milk collected, Denver samples being pooled from *postpartum donors,* while Chicago samples came from donors in later lactation stages.

Section I—Air and Fallout

FISSION PRODUCT BETA ACTIVITY IN AIRBORNE PARTICULATES AND PRECIPITATION

Continuous surveillance of gross beta activity in air and precipitation provides one of the earliest and most sensitive indications of changes in environmental fission product activity. Although this surveillance does not privide enough information to assess human radiation exposure from fallout, it is used as an alerting system for determining when to intensify monitoring in other phases of the environment.

Surveillance data from a number of national programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. Data provided by programs of the Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization are presented individually in tabular form.

1. Radiation Surveillance Network
December 1964

Division of Radiological Health,
Public Health Service

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Surveillance Network (RSN) of the PHS Division of Radiological Health, which regularly gathers samples from 75 stations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

Alerting function

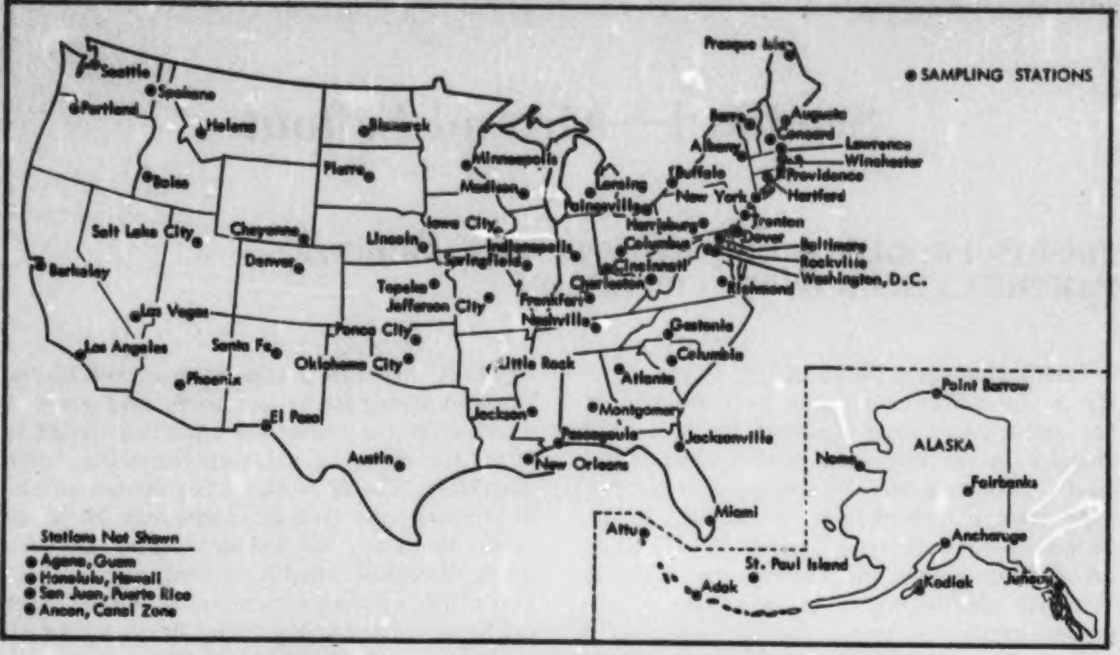
The alerting function of the network is provided by field estimates of the gross beta activity of airborne particulates on the filters. These determinations are performed about 5 hours after the end of the sampling period to allow for decay of naturally-occurring radon daughters. The network station operators telephone any daily field estimates over 10 pc/m^3 to the Radiation Surveillance Center, Division of Radiological Health, Washington, D. C. Lower field estimates are reported to the Center by the laboratory at Rockville, Maryland, which receives a daily written report together with the air filter submitted by each station operator. The filters are counted at the laboratory to confirm field estimates.

Analyses for specific radionuclides may also be made if gross beta activity concentrations are high. All field estimates are reported elsewhere on a monthly basis (*1*). When unusually high air levels are reported, appropriate Federal and State officials are promptly notified.

Air sampling procedure and results

Airborne particulates are collected continuously on carbon-loaded cellulose dust filters 4 inches in diameter. A volume of about 1,800 cubic meters of air is drawn through each filter during the 24-hour sampling period by a high volume centrifugal blower.

The filters are forwarded to the Radiation Surveillance Network laboratory in Rockville, Maryland, where the gross beta activity is measured using a thin-window, gas-flow proportional counter, calibrated with a Sr^{90}–Y^{90} standard. Each filter is counted at least 3 days after the end of the sampling period and again 7 days later. The initial 3-day aging of the sample eliminates interference from naturally-


Seattle
Spokane
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Helena
Boise
Bismarck
Pierre
Minneapolis
Madison
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Cheyenne
Denver
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Atlanta
Montgomery
Pascagoula
Jacksonville
Miami
Point Barrow
ALASKA
Nome
Fairbanks
Attu
Anchorage
St. Paul Island
Adak
Kodiak
Juneau
Stations Not Shown
Agana, Guam
Honolulu, Hawaii
San Juan, Puerto Rico
Ancon, Canal Zone

FIGURE 1. RADIATION SURVEILLANCE NETWORK SAMPLING STATIONS

occurring radon and thoron daughters. By using the two counts and the Way-Wigner formula (*2*), the age of the fission products is estimated, and the activity extrapolated to the time of collection.[1] The daily concentrations and estimated ages of selected samples are reported by the PHS in a monthly RSN report (*1*).

The December *RSN* station average, maximum, and minimum gross beta activities in air are given in table 1. Figure 2 shows time profiles of data compiled since 1958 for eight of the stations.

Precipitation measurements

Continuous sampling for total precipitation is conducted at most stations on a daily basis, using funnels with collection areas of 0.4 square meter. A 500-ml aliquot of the collected precipitation is evaporated to dryness, and the residue is forwarded to the laboratory for analysis. If the collected sample is between 200 and 500 ml, the entire sample is evaporated. When a sample is smaller than 200 ml (equivalent to 0.5 mm or 0.02 inches of rainfall), the volume of precipitation is reported, but no analysis is made.

In the laboratory the gross beta activity in precipitation is determined by counting the evaporated sample by the same method used for analyzing the air filters, including the extrapolation to time of collection. Deposition for the sample is determined by:

$$D = \frac{CP}{1000}$$

where D is the deposition in nc/m², C is the concentration in pc/liter, and P is the depth of precipitation in mm. The individual values of deposition and depth of precipitation are totaled for the month, and the average concentration for the month, $\overline{C}$, is determined by:

$$\overline{C} = \frac{\Sigma D}{\Sigma P} \times 1000$$

The December 1964 average concentrations and total depositions are given in table 1.

---

[1] If a sample contains a mixture of fresh and old fission products, the age estimated by the Way-Wigner formula is some intermediate value; consequently the calculated age of the fresh component will be overestimated.

TABLE 1.—GROSS BETA ACTIVITY IN SURFACE AIR AND PRECIPITATION, DECEMBER 1964

Station location		Air surveillance					Precipitation measurement	
		Number of samples	Gross beta activity (pc/m³)			Last profile in *RHD*	Average concentration (pc/liter)[b]	Total deposition (nc/m²)[b]
			Maximum	Minimum	Average[a]			
Ala:	Montgomery	30	0.53	<0.10	0.20	Aug 64	173.4	22.8
Alaska:	Adak	23	0.50	<0.10	0.22	Nov 64		
	Anchorage	30	0.34	0.11	0.30	Apr 65	6.6	1.5
	Attu	22	0.22	<0.10	0.15	Dec 64		
	Fairbanks	8	0.23	<0.10	<0.14	Aug 64	7.1	1.4
	Juneau	4	0.21	<0.10	<0.13	Sep 64		
	Kodiak	18	1.04	<0.10	0.27	Oct 64		
	Nome	20	0.23	<0.10	<0.13	Feb 65		
	Point Barrow	26	0.22	<0.10	<0.13	Jan 65		
	St. Paul Island	30	0.47	<0.10	<0.19	Mar 65		
Ariz:	Phoenix	30	0.59	0.15	0.34	Sep 64		
Ark:	Little Rock	25	0.34	<0.10	0.18	Sep 64	89.3	18.1
Calif:	Berkeley	29	0.26	<0.10	<0.13	Oct 64	182.1	43.3
	Los Angeles	27	0.53	<0.10	0.24	Feb 65	45.6	9.4
Canal Zone:	Ancon	17	0.24	<0.10	<0.11	Nov 64		
Colo:	Denver	30	0.66	<0.10	0.25	Oct 64	9.1	1.8
Conn:	Hartford	29	0.41	<0.10	0.20	Oct 64	105.5	21.4
Del:	Dover	20	0.57	<0.10	0.24	Aug 64		
D. C:	Washington	28	0.53	<0.10	0.22	Feb 65	60.0	12.5
Fla:	Jacksonville	27	0.58	<0.10	0.26	Sep 64	119.1	24.9
	Miami	27	0.92	<0.10	0.37	Oct 64	79.1	16.0
Ga:	Atlanta	12	0.44	<0.10	<0.16	Apr 65	52.6	12.4
Guam:	Agana	30	0.64	<0.10	0.23	Apr 65		
Hawaii:	Honolulu	30	0.18	<0.10	<0.11	Dec 64	123.2	24.9
Idaho:	Boise	27	0.54	<0.10	<0.19	Dec 64	96.4	16.9
Ill:	Springfield	29	0.43	<0.10	0.21	Feb 65		
Ind:	Indianapolis	26	0.47	<0.10	0.19	Apr 65	86.9	17.6
Iowa:	Iowa City	29	0.46	0.11	0.25	Nov 64	29.8	6.6
Kans:	Topeka	26	0.37	<0.10	0.21	Jul 64	20.7	4.1
Ky:	Frankfort	30	0.50	<0.10	0.25	Feb 65	56.8	12.8
La:	New Orleans	28	0.44	<0.10	<0.18	Feb 65	74.1	14.9
Maine:	Augusta	31	0.68	<0.10	0.26	Mar 64	108.8	26.1
	Presque Isle	24	0.36	<0.10	<0.17	Nov 64		
Md:	Baltimore	27	0.45	<0.10	0.30	Oct 64	20.0	4.0
	Rockville	15	0.50	0.11	0.22	Jan 65		
Mass:	Lawrence	31	0.41	<0.10	0.20	Aug 64	52.0	13.0
	Winchester	27	0.66	<0.10	0.29	Dec 64	85.7	28.4
Mich:	Lansing	30	0.65	<0.10	0.29	Jan 65		
Minn:	Minneapolis	21	0.25	<0.10	0.15	Apr 65	30.0	6.2
Miss:	Jackson	29	0.44	<0.10	<0.20	Mar 65	190.8	40.8
	Pascagoula	10	0.32	<0.10	0.21	Dec 64		
Mo:	Jefferson City	28	0.37	<0.10	0.19	Apr 65	35.3	7.1
Mont:	Helena	29	0.45	<0.10	0.22	Nov 64	21.8	4.0
Nebr:	Lincoln	18	0.73	<0.10	0.32	Mar 65	11.2	3.8
Nev:	Las Vegas	24	0.56	<0.10	0.19	Aug 64		
N. H:	Concord	19	0.49	0.13	0.30	Feb 65		
N. J:	Trenton	31	0.70	<0.10	<0.22	Mar 65	31.8	7.4
N. Mex:	Santa Fe	28	0.28	<0.10	0.18	Nov 64	21.6	5.6
N. Y:	Albany	22	0.41	<0.10	0.21	Apr 65	59.4	11.9
	Buffalo	19	0.61	<0.10	0.27	Nov 64		
	New York	16	0.65	<0.10	0.26	Dec 64		
N. C:	Gastonia	25	0.53	<0.10	<0.24	Nov 64	83.9	17.0
N. Dak:	Bismarck	27	0.47	<0.10	0.19	Jan 65	16.3	3.7
Ohio:	Cincinnati	21	0.38	<0.10	0.18	Aug 64		
	Columbus	30	0.62	<0.10	0.30	Mar 65	86.5	22.9
	Painesville	30	0.66	<0.10	0.31	Oct 64	44.8	10.6
Okla:	Oklahoma City	30	0.38	<0.10	0.20	Jan 65		
	Ponca City	28	0.29	<0.10	<0.13	Oct 64	17.8	4.5
Ore:	Portland	28	0.85	<0.10	0.26	Mar 65	146.4	29.2
Pa:	Harrisburg	31	0.45	<0.10	<0.19	Apr 64	67.2	13.5
P. R:	San Juan	26	0.35	<0.10	<0.15	Mar 65	71.0	14.1
R. I:	Providence	30	0.42	<0.10	0.22	Jan 65	103.8	21.7
S. C:	Columbia	27	0.49	<0.10	<0.19	Dec 64	108.4	24.5
S. Dak:	Pierre	31	0.63	<0.10	0.23	Sep 64		
Tenn:	Nashville	30	0.61	<0.10	0.25	Jan 65	102.6	23.2
Tex:	Austin	31	0.36	<0.10	0.22	Aug 64	29.4	5.9
	El Paso	31	0.57	<0.10	0.31	Jan 65	11.5	2.3
Utah:	Salt Lake City	30	1.13	<0.10	0.32	Feb 65	84.7	18.4
Vt:	Barre	30	0.65	<0.10	0.32	Sep 64	72.2	15.0
Va:	Richmond	31	0.39	<0.10	<0.16	Sep 64	72.2	14.7
Wash:	Seattle	27	0.34	<0.10	<0.14	Jul 64	113.3	23.1
	Spokane	31	0.35	<0.10	<0.14	New		
W. Va:	Charleston	28	0.63	<0.10	0.26	Dec 64	68.2	20.0
Wis:	Madison	30	0.58	<0.10	0.25	Sep 64	7.0	3.7
Wyo:	Cheyenne	27	0.59	<0.10	0.22	Aug 64		
Network summary		1,786	1.15	<0.10	0.21		66.6	12.1

[a] The monthly average is calculated by weighting the individual samples with the length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If the <0.10 values represent more than 10 percent of the average, a less-than sign appears before the average.

[b] Blank indicates no report received.

[c] For the network summary, all averages are arithmetic means of station averages.

6.

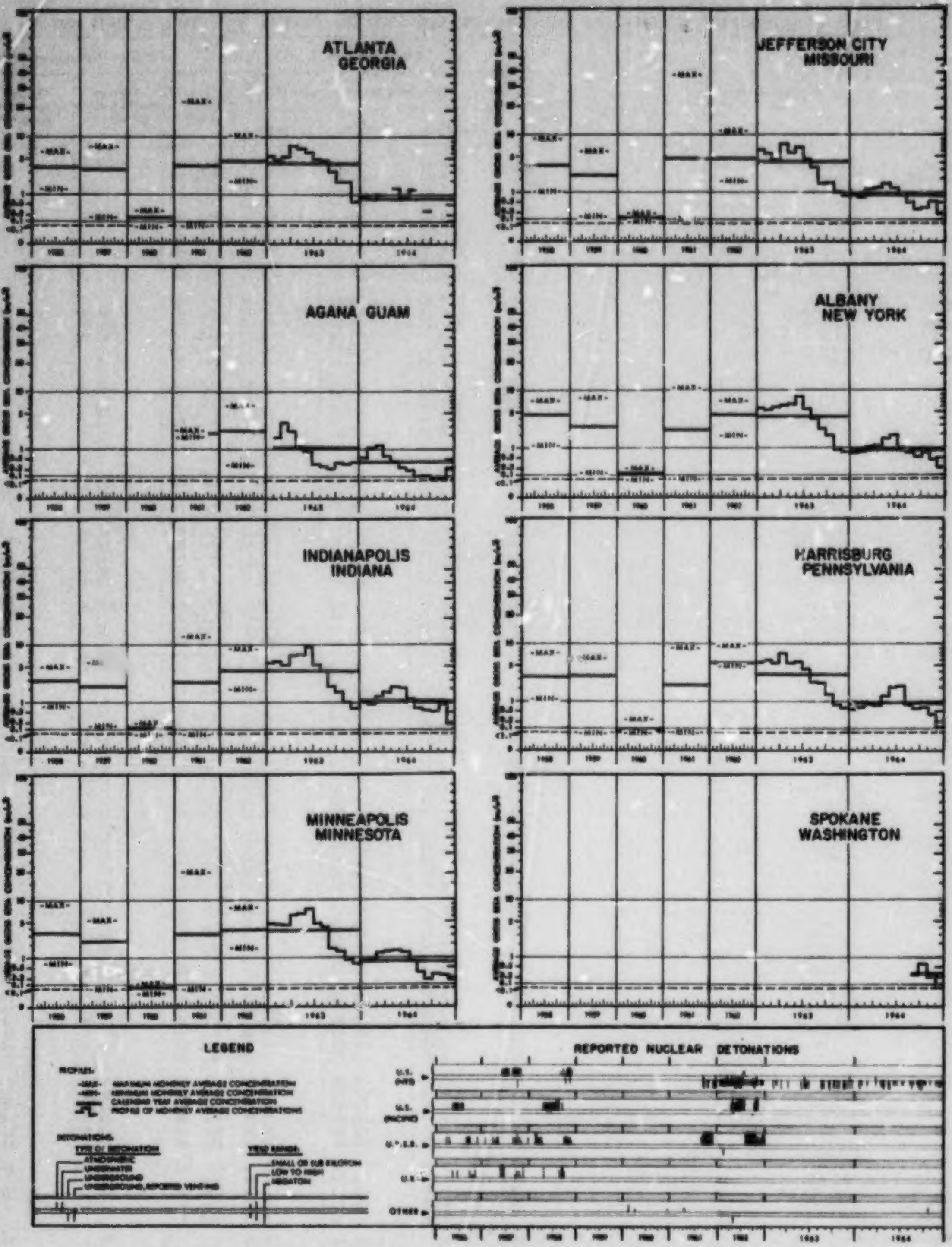

FIGURE 2. MONTHLY AND YEARLY PROFILES OF BETA ACTIVITY IN AIR—RADIATION SURVEILLANCE NETWORK, 1958–DECEMBER 1964

2. National Air Sampling Network Fourth Quarter and Annual Summary 1964

Division of Air Pollution
Public Health Service

The necessity of having basic data on the nature and extent of air pollution throughout the United States led to the organization of the National Air Sampling Network (NASN) in 1953. The NASN analyses air samples for the total quantity of suspended particulate matter, benzene-soluble organic matter, and gross beta radioactivity. Selected samples are also analyzed for nitrates, sulfates, and a number of metals. These analyses aid in the detection of trends in levels of pollution with respect to time, location, population density, climate, and other factors.

Gross beta activity in air

NASN stations (see figure 3) are manned by cooperating Federal, State, and local agencies. The current basic network consists of 110 sampling stations which operate every year in 73 large cities and 37 nonurban areas. In addition, there are stations in 130 cities which operate every other year. Thus, there are 240 sampling stations in all in the NASN network, of which 175 are active in any given year.

Continuous 24-hour samples of suspended particulate matter are taken at each station. The samples, representing approximately 2,000 cubic meters of air, are collected on glass fiber filters on a biweekly random sampling schedule. They are sent for analysis to the Network laboratory at the Robert A. Taft Sanitary Engineering Center in Cincinnati, Ohio. Fourth quarter and annual summary 1964 data appear in tables 2 and 3.

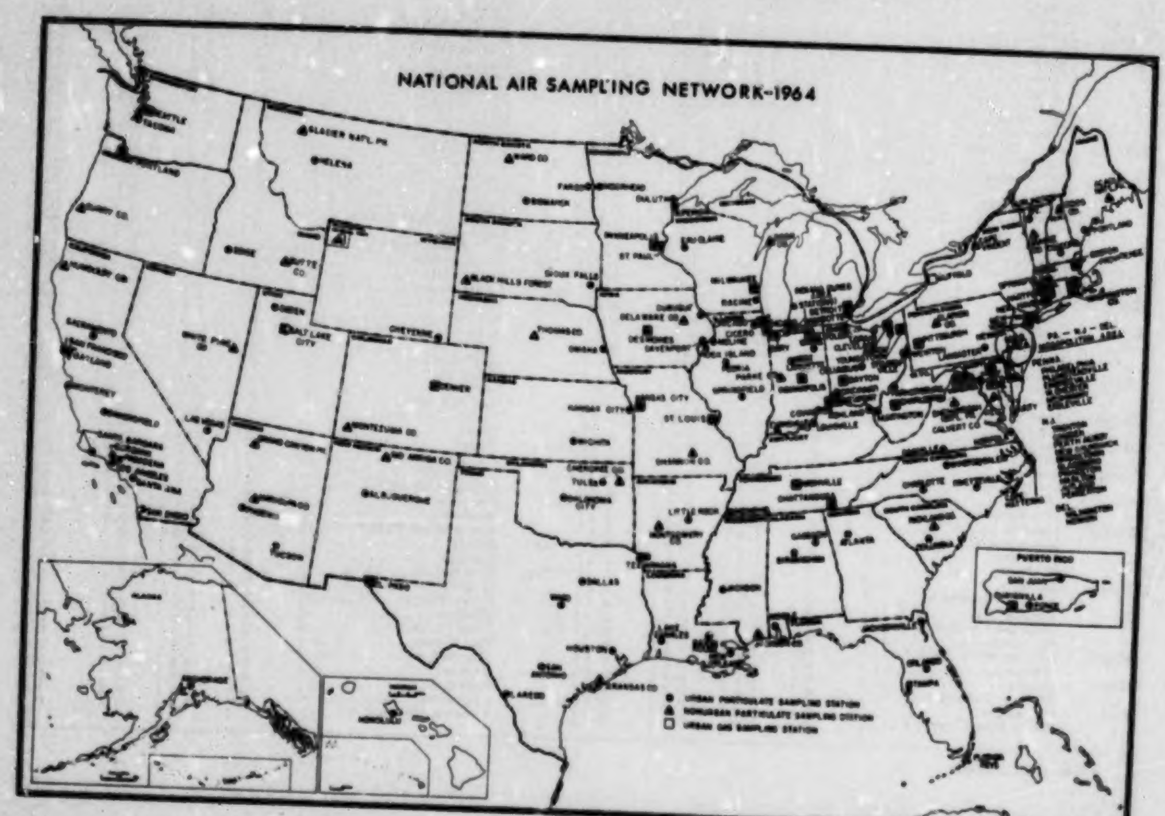
NATIONAL AIR SAMPLING NETWORK-1964
SALT LAKE CITY
CHEYENNE
DENVER
KANSAS CITY
ST LOUIS
DALLAS
PUERTO RICO
● URBAN PARTICULATE SAMPLING STATION
▲ NONURBAN PARTICULATE SAMPLING STATION
☐ URBAN GAS SAMPLING STATION

FIGURE 3. NATIONAL AIR SAMPLING NETWORK STATIONS, 1964

8

TABLE 2.—GROSS BETA ACTIVITY IN SURFACE AIR, NASN, FOURTH QUARTER, 1964

[Concentrations in pc/m³]

Station		Number of samples	Maximum	Minimum	Average
Ala:	Birmingham	6	5.1	0.4	1.3
	Gadsden	6	2.9	0.4	1.0
	Mobile	6	9.3	0.2	2.0
Alaska:	Anchorage	5	0.4	0.1	0.3
Ariz:	Grand Canyon Pk.*	6	1.0	0.2	0.6
	Maricopa County *	6	1.2	0.3	0.8
	Phoenix	6	1.3	0.2	0.7
	Tucson	5	0.9	0.3	0.6
Ark:	Little Rock	6	2.5	0.1	0.8
	Montgomery County *	6	1.7	0.4	0.7
	Texarkana	6	2.4	0.2	0.7
Calif:	Bakersfield	6	1.3	0.2	0.6
	Burbank	5	0.9	0.3	0.5
	Humboldt County *	5	0.5	0.1	0.2
	Los Angeles	6	0.8	0.2	0.5
	Monterey	5	0.9	0.4	0.5
	Oakland	6	0.9	0.3	0.6
	Pasadena	6	1.1	0.2	0.5
	Sacramento	6	0.6	0.1	0.3
	San Diego	5	0.8	0.3	0.5
	San Francisco	6	0.9	0.1	0.5
	Santa Ana	6	0.7	0.1	0.4
	Santa Barbara	5	0.9	0.2	0.5
Colo:	Denver	6	9.5	0.2	1.9
	Montezuma County *	6	1.6	0.2	0.6
Conn:	Hartford	5	0.5	0.2	0.3
	New Haven	6	0.8	0.1	0.3
Del:	Kent County *	6	0.5	0.1	0.3
	Newark	6	0.6	0.2	0.4
	Wilmington	6	8.4	0.3	1.7
D. C:	Washington	5	7.2	0.1	1.4
Fla:	Florida Keys *	7	1.7	0.1	0.5
	Jacksonville	7	12.4	0.1	2.1
	Orlando	5	10.0	0.3	4.2
Ga:	Atlanta	6	3.8	0.4	1.2
Hawaii:	Honolulu	6	2.1	0.1	0.5
Idaho:	Boise	6	1.2	0.2	0.6
	Butte County *	6	4.0	0.4	1.6
Ill:	Chicago	6	1.5	0.2	0.5
	Cicero	5	0.5	0.2	0.3
	Moline	6	1.1	0.1	0.4
	Peoria	5	1.0	0.2	0.5
	Rock Island	6	1.8	0.3	0.7
	Springfield	6	1.5	0.3	0.6
Ind:	East Chicago	6	0.7	0.2	0.4
	Evansville	5	1.7	0.2	0.6
	Fort Wayne	6	2.4	0.2	0.7
	Gary	5	1.9	0.2	0.7
	Indianapolis	6	2.5	0.2	0.8
	Lafayette	5	0.6	0.1	0.3
	Parke County *	6	2.4	0.2	0.7
Iowa:	Davenport	6	1.8	0.1	0.6
	Delaware County *	6	1.2	0.2	0.5
	Des Moines	5	1.6	0.2	0.7
	Dubuque	6	1.4	0.2	0.7
Kans:	Kansas City	6	0.7	0.2	0.4
	Wichita	6	0.7	0.3	0.4
Ky:	Ashland	7	4.0	0.3	0.9
	Covington	6	4.2	0.1	1.1
	Louisville	5	1.3	0.2	0.6
La:	Baton Rouge	6	6.4	0.2	1.5
	Lake Charles	6	2.3	0.2	0.8
	New Orleans	6	6.8	0.3	1.6
Maine:	Acadia Nat'l. Park *	5	2.2	0.2	1.0
	Portland	6	2.7	0.2	0.7
Md:	Baltimore	6	3.7	0.3	1.0
	Calvert County *	6	5.7	0.2	1.2
Mass:	Boston	6	0.5	0.2	0.3
	Springfield	5	0.5	0.2	0.3
Mich:	Detroit	6	2.5	0.3	0.7
	Wyandotte	2	0.4	0.2	0.3
Minn:	Duluth	6	2.0	0.2	0.6
	Minneapolis	6	1.3	0.2	0.4
	Moorhead	6	0.8	0.2	0.4
	St. Paul	6	1.5	0.2	0.5
Miss:	Jackson	4	0.8	0.4	0.6
	Jackson County *	6	12.6	0.3	2.6
Mo:	Kansas City	6	0.6	0.2	0.4
	Shannon County *	6	3.0	0.2	0.9
	St. Louis	6	1.5	0.1	0.5
Mont:	Glacier Nat'l. Park *	6	1.1	0.1	0.4
	Helena	6	1.7	0.2	0.6
Nebr:	Omaha	6	2.7	0.2	0.9
	Thomas County *	6	2.9	0.2	0.8
Nev:	Las Vegas	6	1.4	0.3	0.7
	White Pine County *	6	1.3	0.1	0.5
N. H:	Concord	6	1.0	0.2	0.4
	Coos County *	6	2.1	0.2	0.6
N. J:	Bridgeton	6	0.7	0.2	0.4
	Camden	6	0.7	<0.1	0.4
	Jutland	5	0.6	0.1	0.4
	Marlton	6	1.6	0.1	0.5
	Newark	6	0.6	0.2	0.3
	New Brunswick	3	0.7	0.3	0.5
	Pemberton	5	0.6	0.2	0.4
	Perth Amboy	7	2.5	0.1	0.6
	Princeton	3	0.5	0.3	0.4
	Trenton	6	0.7	0.2	0.3
	Glassboro	5	0.8	0.2	0.4
N. Mex:	Albuquerque	6	2.1	0.2	0.8
	Rio Arriba County *	6	1.2	0.3	0.6
N. Y:	Cape Vincent *	6	1.4	0.2	0.5
	New York	6	0.9	0.2	0.5
N. C:	Cape Hatteras *	6	2.9	0.2	0.8
	Charlotte	6	3.2	0.3	0.9
	Fayetteville	6	6.2	0.1	1.3
	Winston Salem	6	5.1	0.3	1.2
N. Dak:	Bismarck	6	0.6	0.2	0.4
	Fargo	6	0.8	0.1	0.5
	Ward County *	7	0.7	0.1	0.3
Ohio:	Akron	6	4.4	0.1	1.1
	Cincinnati	5	2.9	0.4	1.0
	Cleveland	6	3.2	0.2	0.9
	Columbus	6	4.4	0.1	1.2
	Dayton	6	3.1	0.1	0.9
	Lorain	6	2.0	0.1	0.6
	Steubenville	6	4.0	0.1	1.0
	Toledo	6	2.6	0.2	0.8
	Youngstown	6	5.4	<0.1	1.2
Okla:	Cherokee County *	6	1.0	0.1	0.4
	Oklahoma City	7	0.8	0.2	0.5
	Tulsa	6	1.9	0.2	0.6
Ore:	Curry County *	6	0.9	0.1	0.3
	Portland	6	0.9	0.1	0.4
Pa:	Clarion County *	7	6.3	<0.1	1.2
	Eagleville	4	0.5	0.2	0.4
	Embreeville	6	0.5	0.1	0.3
	Lancaster	7	3.4	0.1	0.8
	Philadelphia	5	0.9	0.2	0.5
	Pittsburgh	6	6.1	0.1	1.3
	Sanatoga	2	0.3	0.1	0.2
	West Chester	2	0.2	0.1	0.2
P. R:	Guayanilla	7	0.5	0.1	0.2
	Ponce	6	0.5	0.1	0.2
	San Juan	6	0.3	0.1	0.2
R. I:	Providence	7	2.2	0.2	0.6
	Washington County *	6	0.7	0.2	0.4
S. C:	Columbia	5	1.7	0.1	0.9
	Richland County *	5	5.1	0.1	1.2
S. Dak:	Black Hills *	6	3.9	0.3	1.4
	Sioux Falls	6	2.1	0.1	0.5
Tenn:	Chattanooga	5	3.1	0.3	1.1
	Memphis	6	3.4	<0.1	1.2
	Nashville	6	2.5	0.3	0.8
Tex:	Aransas County *	[illegible]	1.7	0.1	0.6
	Dallas	6	1.9	0.3	0.8
	El Paso	6	2.5	0.3	1.0
	Houston	6	1.9	0.3	0.7
	Laredo	4	1.1	0.2	0.5
	San Antonio	6	0.7	0.1	0.5
	Texarkana	6	2.1	0.2	0.7
	Waco	6	0.9	0.4	0.6
Utah:	Ogden	7	3.4	0.1	1.0
	Salt Lake C[illegible]	5	1.7	0.1	0.7
Vt:	Burlington	5	0.8	0.2	0.4
	Orange County *	6	1.2	0.2	0.4
Va:	Danville	6	5.2	0.4	1.2
	Norfolk	6	4.7	0.2	1.1
	Shenandoah Park *	7	9.8	0.3	1.8
Wash:	Seattle	6	0.5	0.1	0.2
	Tacoma	6	0.6	0.1	0.3
W. Va:	Charleston	6	2.6	0.2	0.9
	Huntington	6	3.3	0.4	1.0
	Parkersburg	6	4.7	0.1	1.0
	Weirton	6	1.6	0.1	0.6
Wis:	Door County *	5	1.8	0.3	0.7
	Eau Claire	6	1.7	0.2	0.5
	Milwaukee	6	1.2	0.3	0.5
	Racine	6	0.8	0.2	0.4
	Superior	6	1.7	0.2	0.5
Wyo:	Cheyenne	6	4.1	0.2	1.0
	Yellowstone Park *	6	2.8	0.1	0.7

* Nonsuburban Stations

TABLE 3.—FISSION PRODUCT GROSS BETA ACTIVITY IN SURFACE AIR, NASN, ANNUAL SUMMARY, 1964

[Concentrations in pc/m³]

Station		Number of samples	Maximum	Minimum	Average
Ala:	Birmingham	26	5.1	0.1	1.4
	Gadsden	26	3.3	0.1	1.3
	Mobile	26	9.3	0.2	1.7
Alaska:	Anchorage	24	3.8	0.1	0.7
Ariz:	Grand Canyon Pk.*	25	5.0	0.2	1.7
	Maricopa County *	26	8.0	0.1	2.4
	Phoenix	26	5.4	0.1	2.0
	Tucson	25	6.5	0.1	1.8
Ark:	Little Rock	25	2.6	0.1	1.2
	Montgomery County	24	5.5	0.3	1.6
	Texarkana	24	2.9	0.1	1.1
Calif:	Bakersfield	25	5.6	0.2	1.5
	Burbank	24	6.5	0.3	1.7
	Humboldt County *	23	3.0	0.1	0.5
	Los Angeles	26	4.7	0.2	1.2
	Monterey	22	3.6	0.2	1.1
	Oakland	25	3.6	0.1	0.9
	Pasadena	26	5.0	0.2	1.6
	Sacramento	26	4.9	0.1	1.1
	San Diego	25	4.0	0.3	1.5
	San Francisco	26	3.3	<0.1	0.9
	Santa Ana	25	3.2	0.1	1.2
	Santa Barbara	26	4.0	0.2	1.1
Colo:	Denver	26	9.5	0.2	2.0
	Montezuma County *	26	5.7	0.2	1.6
Conn:	Hartford	23	3.5	0.1	1.4
	New Haven	26	4.9	0.1	1.3
Del:	Kent County *	23	4.4	0.1	1.3
	Newark	16	3.7	0.2	1.1
	Wilmington	26	8.4	0.3	1.7
D. C:	Washington	26	7.2	<0.1	1.6
Fla:	Florida Keys *	21	4.1	0.1	1.3
	Jacksonville	26	12.4	0.1	1.7
	Orlando	20	19.0	0.3	2.6
	Tampa	19	5.7	0.1	2.2
Ga:	Atlanta	26	3.8	0.2	1.4
Hawaii:	Honolulu	26	2.2	0.1	0.8
Idaho:	Boise	26	4.2	0.2	1.5
	Butte County *	26	5.5	0.4	1.8
Ill:	Chicago	21	3.2	0.1	1.1
	Cicero	21	4.0	0.2	1.4
	Moline	24	3.4	0.1	1.1
	Peoria	23	2.7	0.2	1.1
	Rock Island	24	4.6	0.3	1.7
	Springfield	15	1.8	0.3	0.7
Ind:	East Chicago	23	2.4	0.2	1.0
	Evansville	23	3.9	0.2	1.3
	Fort Wayne	25	4.1	0.2	1.5
	Gary	21	3.7	0.2	1.4
	Indianapolis	26	3.8	0.2	1.5
	Lafayette	22	2.5	0.1	1.1
	Parke County *	26	2.9	0.2	1.2
Iowa:	Davenport	23	3.1	0.1	1.3
	Delaware County *	24	2.3	0.2	1.0
	Des Moines	25	3.6	0.2	1.5
	Dubuque	26	2.8	0.1	1.2
Kans:	Kansas City	25	3.3	0.2	1.1
	Wichita	25	3.8	0.3	1.3
Ky:	Ashland	24	6.5	0.3	1.7
	Covington	24	5.7	0.1	1.6
	Louisville	21	3.0	0.2	1.2
La:	Baton Rouge	26	6.4	<0.1	1.4
	Lake Charles	26	3.4	<0.1	1.1
	New Orleans	26	6.8	0.1	1.6
Maine:	Acadia Nat'l. Park *	23	3.9	0.2	1.4
	Portland	24	3.5	0.2	1.3
Md:	Baltimore	24	4.3	0.2	1.5
	Calvert County *	26	5.7	0.2	1.7
Mass:	Boston	26	4.4	0.2	1.3
	Springfield	24	3.8	0.1	1.2
Mich:	Detroit	26	4.3	0.3	1.4
	Wyandotte	18	4.7	0.2	1.8
Minn:	Duluth	25	2.7	0.2	1.1
	Minneapolis	26	2.7	0.1	1.0
	Moorhead	25	3.2	0.2	1.2
	St. Paul	26	2.6	0.1	1.1
Miss:	Jackson	24	3.3	<0.1	1.3
Mo:	Jackson County *	20	12.6	0.1	1.7
	Kansas City	25	4.2	0.2	1.4
	Shannon County *	35	3.6	0.1	1.7
	St. Louis	26	3.1	0.1	1.2
Mont:	Glacier Nat'l. Park *	24	2.5	0.1	0.8
	Helena	26	4.7	0.1	1.3
Nebr:	Omaha	26	4.3	0.1	1.7
	Thomas County *	24	6.4	0.2	1.6
Nev:	Las Vegas	25	4.9	0.2	1.8
	White Pine County *	23	4.6	0.1	1.5
N. H:	Concord	24	3.3	0.1	1.2
	Coos County *	25	3.4	0.1	1.2
N. J:	Bridgeton	14	4.2	<0.1	1.0
	Camden	26	4.6	<0.1	1.5
	Jutland	20	4.2	0.1	1.6
	Marlton	18	5.8	0.1	1.6
	Newark	26	3.8	0.2	1.3
	New Brunswick	22	3.5	0.1	1.4
	Pemberton	18	4.4	<0.1	1.3
	Perth Amboy	20	5.2	<0.1	1.4
	Princeton	18	3.8	0.3	1.4
	Trenton	22	3.3	0.1	1.1
	Glassboro	23	4.5	0.2	1.5
N. Mex:	Albuquerque	26	5.8	0.1	1.8
	Rio Arriba County *	26	4.9	0.3	1.8
N. Y:	Cape Vincent *	26	3.2	0.2	1.2
	New York	26	5.7	0.2	1.4
N. C:	Cape Hatteras *	25	6.4	0.1	1.5
	Charlotte	25	4.1	0.1	1.3
	Fayetteville	24	6.2	0.1	1.8
	Winston Salem	25	5.1	0.2	1.6
N. Dak:	Bismarck	26	6.1	0.2	1.4
	Fargo	25	3.3	0.1	1.2
	Ward County *	26	5.3	0.1	1.3
Ohio:	Akron	26	4.4	0.1	1.5
	Cincinnati	25	6.0	0.3	1.8
	Cleveland	26	3.2	0.2	1.3
	Columbus	26	6.5	0.1	1.6
	Dayton	26	8.8	0.1	1.6
	Lorain	25	3.1	0.1	1.2
	Steubenville	24	4.0	0.1	1.4
	Toledo	26	6.5	0.1	1.6
	Youngstown	26	5.4	<0.1	1.5
Okla:	Cherokee County *	26	5.0	0.1	1.3
	Oklahoma City	25	4.6	0.2	1.4
	Tulsa	26	3.9	0.1	1.3
Ore:	Curry County *	19	1.5	0.1	0.4
	Portland	25	3.5	0.1	0.8
Pa:	Clarion County *	22	6.3		1.4
	Embreeville	19	3.4	0.1	1.0
	Lancaster	25	4.5	0.1	1.5
	Philadelphia	25	4.4	<0.1	1.5
	Pittsburgh	26	6.1	0.1	1.5
P. R:	Guayanilla	26	3.3	0.1	1.0
	Ponce	26	3.2	0.1	1.1
	San Juan	25	3.2	0.1	1.0
R. I:	Providence	23	4.0		1.3
	Washington County *	26	5.1	0.1	1.5
S. C:	Columbia	21	4.6	0.1	1.5
	Richland County *	23	5.1	0.1	1.5
S. Dak:	Black Hills *	26	4.9	0.3	1.8
	Sioux Falls	25	2.5	0.1	1.2
Tenn:	Chattanooga	24	5.1	0.3	1.5
	Memphis	24	5.7	<0.1	1.6
	Nashville	26	3.5	<0.1	1.4
Tex:	Aransas County *	26	3.1	<0.1	1.3
	Dallas	26	3.2	0.1	1.3
	El Paso	26	8.3	0.1	2.3
	Houston	24	4.5	<0.1	1.2
	Laredo	19	5.2	<0.1	0.9
	San Antonio	25	5.1	0.1	1.4
	Texarkana	24	3.8	0.1	1.2
	Waco	26	3.9	0.2	1.3
Utah:	Ogden	26	3.4	0.1	1.6
	Salt Lake City	24	5.2	0.1	1.7
Vt:	Burlington	23	4.2	0.1	1.2
Va:	Orange County *	26	3.1	0.1	1.2
	Danville	25	6.1	0.2	1.9
	Norfolk	26	5.6	0.2	1.7
	Shenandoah Park *	26	9.8	0.3	1.7
Wash:	Seattle	26	1.7	0.1	0.5
	Tacoma	25	1.9	0.1	0.5
W. Va:	Charleston	26	5.2	0.1	1.5
	Huntington	24	6.8	<0.1	1.7
	Parkersburg	26	6.3	0.1	1.6
	Weirton	21	4.2	0.1	1.5
Wis:	Door County *	23	2.9	0.2	1.3
	Eau Claire	26	3.1	0.2	1.3
	Milwaukee	26	3.5	0.3	1.2
	Racine	26	2.7	0.2	1.1
	Superior	24	2.2	0.1	0.9
Wyo:	Cheyenne	25	5.4	0.2	1.7
	Yellowstone Park *	26	3.0	0.1	1.2

* Nonurban stations.

3. Canadian Air Monitoring Program[3] December 1964

Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (see figure 4), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*3–7*).

Air

Each air sample involves the collection of particulates from about 650 cubic meters of air drawn through a high-efficiency 4-inch-diameter glass fiber filter during a 24-hour period. These filters are sent daily to the Radiation Protection Division Laboratory in Ottawa. At the laboratory, a 2-inch-diameter disk is cut from each filter and counted with a thin-end-window, gas-flow, Geiger-Mueller counter system calibrated with a Sr^{90}–Y^{90} standard. Four successive measurements are made on each filter to permit correction for natural activities and for the decay of short-lived fission products. The results are extrapolated to the end of the sampling period. Canadian air data for December 1964 are given in table 4.

Precipitation

The amount of radioactive fallout deposited on the ground is determined from measurements on material collected in special polyethylene-lined rainfall pots. The collection period for each sample is one month. After transfer of the water to the sample container, the polyethylene liner is removed, packed with the sample, and sent to the laboratory.

Strontium and cesium carriers are added to all samples on arrival at the laboratory. Other carriers are also added to selected samples according to the specific radionuclides to be determined. The samples are then filtered and the filtrate evaporated to near dryness. The filter paper containing insoluble matter is ignited together with the polyethylene liner at 450 degrees C. The ash is combined with the soluble fraction, transferred to a glass planchet,

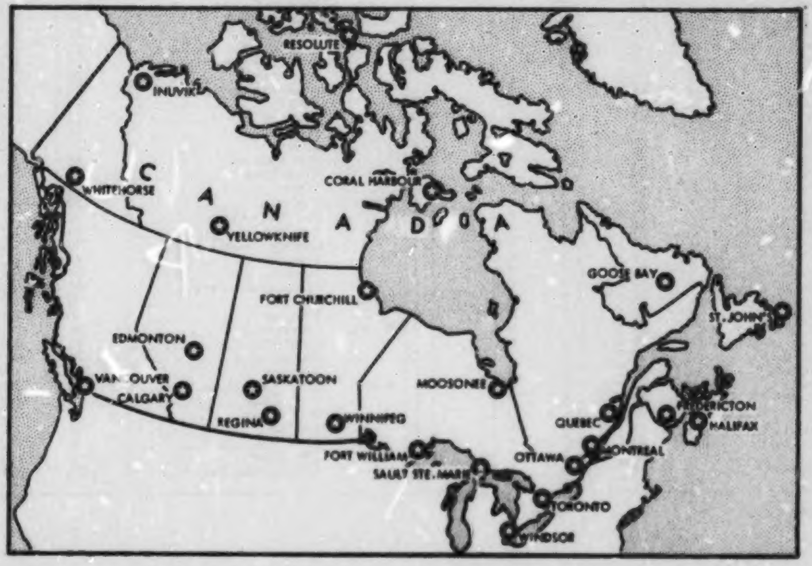

FIGURE 4. CANADIAN AIR AND PRECIPITATION SAMPLING STATIONS

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[3] Data from RADIATION PROTECTION DIVISION. *Radiation Protection Programs*, Vol. 3, No. 1: 45–46 (January 1965), Canadian Department of National Health and Welfare, Ottawa, Canada.

TABLE 4.—GROSS BETA ACTIVITY IN SURFACE AIR AND PRECIPITATION, CANADA, DECEMBER 1964

Station location	Air surveillance				Precipitation measurements	
	Number of samples	Gross beta activity (pc/m^3)			Average concentration (pc/liter)	Total deposition (nc/m^2)
		Maximum	Minimum	Average		
Calgary	31	0.5	0.1	0.3	96	2.3
Coral Harbour	29	0.3	0.1	0.2	80	0.9
Edmonton	31	0.4	0.1	0.3	162	3.0
Ft. Churchill	30	0.3	0.1	0.2	trace	1.2
Ft. William	31	0.4	0.2	0.2	120	5.1
Fredericton	31	0.3	0.0	0.1	33	5.8
Goose Bay	31	0.4	0.0	0.2	78	4.2
Halifax	21	0.3	0.0	0.2	57	11.4
Inuvik	31	0.5	0.2	0.3	69	2.0
Montreal	31	0.4	0.1	0.2	125	9.4
Moosonee	31	0.3	0.1	0.2	88	2.5
Ottawa	30	0.3	0.1	0.2	74	5.2
Quebec	31	0.4	0.1	0.2	100	11.7
Regina	31	0.4	0.1	0.2	95	2.1
Resolute	30	0.4	0.1	0.2	356	3.6
St. John's, Nfld	26	0.4	0.0	0.2	54	9.4
Saskatoon	16	0.3	0.0	0.1	171	2.8
Sault Ste. Marie	31	0.3	0.1	0.2	67	7.4
Toronto	30	0.5	0.1	0.2	141	7.3
Vancouver	30	0.3	0.0	0.2	86	12.7
Whitehorse	31	0.3	0.0	0.2	37	1.0
Windsor	29	0.4	0.1	0.2	79	5.8
Winnipeg	31	0.5	0.2	0.3	71	2.2
Yellowknife	30	0.3	0.1	0.2	166	0.9
Network summary	704	0.5	0.0	0.2	104	5.0

evaporated under an infra-red lamp, and then counted with a thin-end-window Geiger-Mueller counter calibrated with a Sr^{90}–Y^{90} source. Gross beta activities for December 1964 samples are given in table 4. Radionuclide analyses are reported quarterly in RHD.

4. Mexican Air Monitoring Program
December 1964

National Commission of Nuclear Energy

The Radiation Surveillance Network of Mexico was established by the Comisión Nacional de Energía Nuclear (CNEN), Mexico City. From 1952 to 1961 the network was directed by the Institute of Physics of the University of Mexico, under contract to the CNEN (*8–12*).

In 1961 the CNEN appointed its Division of Radiological Protection to establish a new Radiation Surveillance network. This network consists of 17 stations (see figure 5), twelve of which are located at airports and operated by airline personnel. The remaining five stations are located at Mexico City, Mérida, Veracruz, San Luis Potosí, and Ensenada. Staff members of the DRP operate the Station at Mexico City, while the other four stations are manned by members of the Centro de Previsión del Golfo de México, the Chemistry Department of the University of Mérida, the Institute de Zonas Desérticas of the University of San Luis Potosí, and the Escuela Superior de Ciencias Marinas of the University of Baja California, respectively.

Sampling

The sampling procedure involves drawing air for 24 hours a day, 3 or 4 days a week at the rate of approximately 1,200 cubic meters per day, through a high-efficiency, 6 x 8-inch glass fiber filter, using high volume samplers. After each 24 hour sampling period, the filter is removed and forwarded via air mail to the "Laboratorio de Estudios sobre Contaminación Radiactiva", CNEN, in Mexico City for assay of gross beta activity. A minimum of 3 or 4 days after collection is allowed for decay of

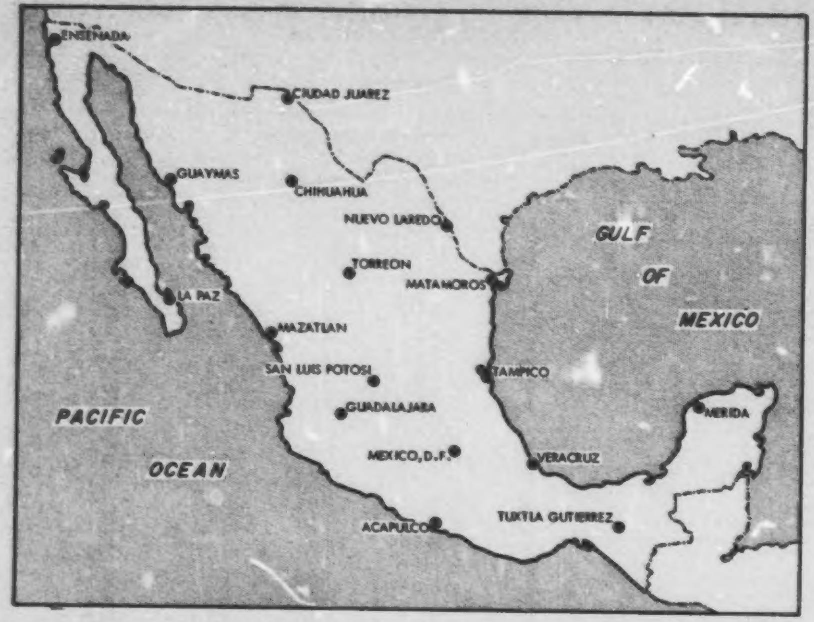
ENSENADA
CIUDAD JUAREZ
GUAYMAS
CHIHUAHUA
NUEVO LAREDO
TORREON
MATAMOROS
LA PAZ
MAZATLAN
SAN LUIS POTOSI
TAMPICO
GUADALAJARA
MERIDA
MEXICO, D.F.
VERACRUZ
TUXTLA GUTIERREZ
ACAPULCO
GULF
OF
MEXICO
PACIFIC
OCEAN

FIGURE 5. FALLOUT NETWORK SAMPLING STATIONS IN MEXICO

radon and thoron daughter natural radioactivity. Data are not extrapolated to time of collection.

Results

The maximum, minimum, and average fission product beta concentrations in surface air during December 1964 are presented in table 5.

TABLE 5.—GROSS BETA ACTIVITY OF AIRBORNE PARTICULATES, MEXICO, DECEMBER 1964

Station	Number of Samples	Gross beta activity (pc/m³)		
		Maximum	Minimum	Average
Acapulco	9	<0.1	<0.1	<0.1
Ciudad Juárez	15	0.4	<0.1	0.2
Chihuahua	18	0.3	<0.1	0.1
Ensenada	8	0.3	0.1	0.2
Guadalajara	18	1.2	<0.1	0.1
Guaymas	10	0.7	<0.1	0.2
La Paz	20	0.5	<0.1	0.2
Matamoros	4	<0.1	<0.1	<0.1
Mazatlán [a]				
Mérida	9	0.2	<0.1	0.1
México, D.F.	15	0.1	<0.1	0.1
Nuevo Laredo	10	0.5	<0.1	0.2
San Luis Potosí	14	0.2	<0.1	<0.1
Tampico	16	0.3	<0.1	0.1
Torreón	24	0.5	<0.1	0.1
Tuxtla Gutiérrez [a]				
Veracruz	21	0.3	<0.1	0.1

[a] Blank indicates station temporarily shut down.

5. Pan American Air Sampling Program December 1964

Pan American Health Organization and Public Health Service

Gross beta activity in air is monitored by four countries in the Americas under the auspices of a collaborative program developed by the Pan American Health Organization and the Public Health Service (PHS) for assisting countries of the Americas in developing radiological health programs. The sampling equipment and analytical services are provided by the Division of Radiological Health, PHS, and are identical with those employed for the Radiation Surveillance Network.

The four air sampling stations included in the Program are operated by the technical staff of the Ministry of Health in each country. The station in Kingston, Jamaica, is operated by the Public General Hospital; in Caracas, Venezuela, by the Venezuelan Institute for Scientific Investigations; in Lima, Peru, by the Institute of Occupational Health; and in Santiago, Chile, by the Occupational Health Service.

The Kingston station began operation in March 1964, and the other three were started near the end of 1962.

The December 1964 air monitoring results from the four participating countries are given in table 6.

TABLE 6.—GROSS BETA ACTIVITY IN AIR, DECEMBER 1964

[Concentrations in pc/m³]

Sampling stations	No. of samples	Maximum	Minimum	Average ᵃ
Kingston, Jamaica	21	0.19	<0.10	0.12
Caracas, Venezuela	9	<0.10	<0.10	<0.10
Lima, Peru	0	—	—	—
Santiago, Chile	29	0.23	<0.10	0.13

ᵃ The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If the <0.10 values represent more than 10 percent of the average, a less-than sign is placed in front of the average.

6. Gross beta activity in air, North America December 1964

Beginning with January 1963 data, monthly average concentrations of airborne gross beta activity in Canada and the United States have been presented in combined form as isogram maps of most of North America. The data from the Radiation Surveillance Network and the Canadian Air Network may be adjusted to each other by means of an intercalibration factor derived by Lockhart and Patterson (*13*). Because of extremely low levels of gross beta activity in air during December 1964, the isogram presentation is omitted.

With the formation of the Mexican Air Monitoring Program, new intercalibration ratios were determined, this time including the Canadian Network, Radiation Surveillance Network, Pan American Air Sampling Program, National Air Sampling Network, the HASL 80th Meridian Network, and the Mexican Network (*14*). The new intercalibration factors reflect some changes in standardization in both the RSN and the Canadian Air Network, effective September 1963. The RSN and Pan American data were multiplied by an intercalibration factor of 1.28, and the Mexican data were multiplied by 0.81 in order to adjust them to Canadian data.

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DETECTION OF FALLOUT FROM CHINESE NUCLEAR TEST OF OCTOBER 16, 1964, BY THE NATIONAL AIR SAMPLING NETWORK

B. Branson[1], *E. Tabor*[1], *G. Holzworth*[2], *S. Gold*[1], *J. Hardin*[1], *and B. Kahn*[1]

Beginning October 21, 1964, air filters from the NASN stations shown in figure 1 were analyzed for recently formed fission products resulting from the mainland Chinese atmospheric nuclear test. Samples were taken daily by or for the Division of Air Pollution at Los Angeles, St. Louis, and Washington; Cincinnati samples were collected daily by personnel of Radiological Health Research Activities. Seven additional stations along the northern boundary and west coast of the United States sampled daily between October 21 and 27. On October 28 all NASN stations collected their regular biweekly 24-hour sample for gross beta activity concentration measurement; the results are shown in figure 2.

At each station, suspended particular matter was collected with a high-volume pump on an 8- by 10-inch glass fiber filter over a 24-hour period from approximately 2,000 cubic meters of air. After collection the filters were removed and sent to the Robert A. Taft Sanitary Engineering Center for analysis. Gross beta activity from fallout was measured with an end-window proportional counter 4 or more days after collection so that the contribution of activity from the short-lived radioactive daughters of the naturally occurring radon and thoron would be eliminated. The radioactivity concentration, in picocuries per cubic meter of air (pc/m^3), was determined by:

$$pc/m^3 = \frac{KC}{FEV}$$

where K — pc/dpm
C — count rate, cpm
F — self-absorption factor
E — counter efficiency, cpm/dpm
V — air volume, m^3.

Any significant increase in gross activity alerted the counting room to obtain a gamma scan of the filter. The gamma radiation was measured with a 4 x 4-inch NaI (Tl) crystal and a 200-channel spectrometer. In many of the samples it was possible to identify 12.8-day Ba^{140}-La^{140}, 3.2-day Te^{132}-I^{132}, 2.8-day Mo^{99}, and 2.4-day Np^{239} based upon rates of decay and characteristic gamma peak energies. The presence of Np^{239} results from the decay of U^{239}, the neutron activation product of U^{238}; the other radionuclides are common fission products.

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[1] Messrs. Branson, Gold, and Hardin are staff members and Dr. Kahn is Chief of Radiological Health Research Activities, Division of Radiological Health, and Dr. Tabor is Chief of the National Air Sampling Laboratory of Engineering and Physical Sciences, Division of Air Pollution; both of these Divisions are agencies of the Public Health Service, U.S. Department of Health, Education and Welfare, Robert A. Taft Sanitary Engineering Center, Cincinnati, Ohio.

[2] Mr. Holzworth is the Supervisory Research Meteorologist of the U.S. Weather Bureau Research Station, Cincinnati, Ohio.

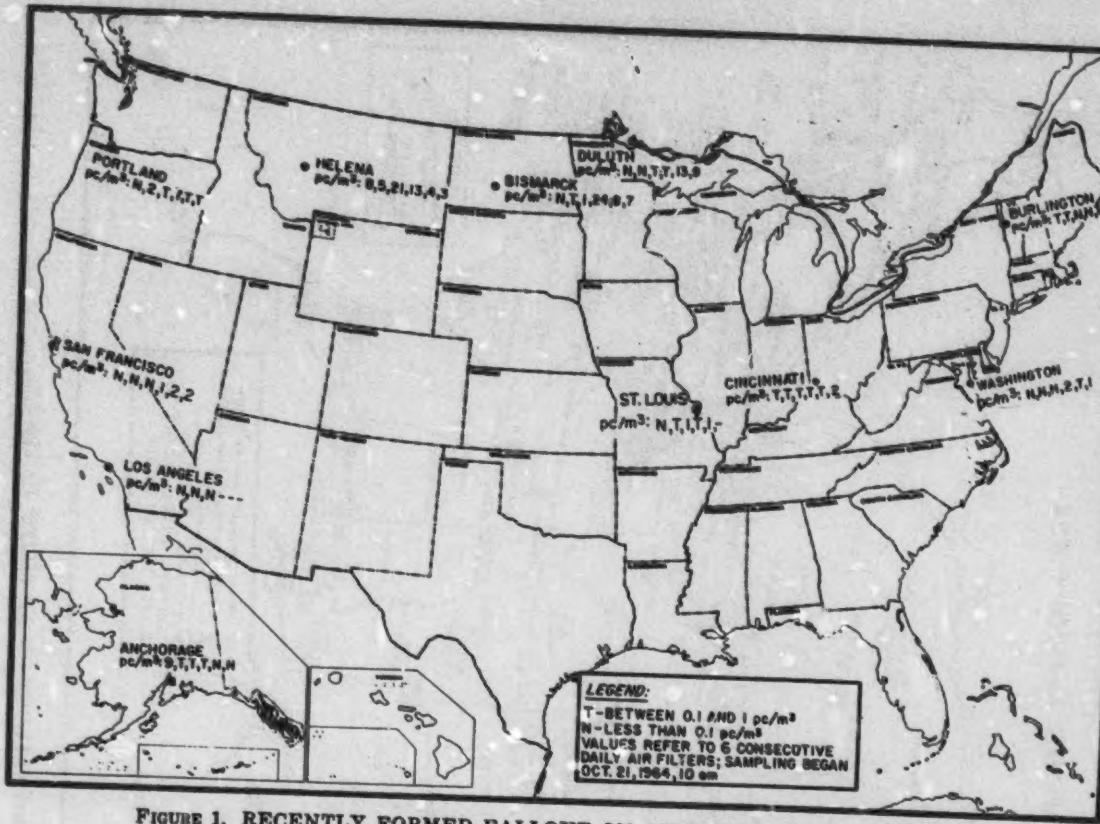
PORTLAND
pc/m³: N,2,T,I,T,T
HELENA
pc/m³: 8,5,21,13,4,3
BISMARCK
pc/m³: N,T,1,24,8,7
DULUTH
pc/m³: N,N,T,T,13,9
BURLINGTON
pc/m³: T,T,N,N,T,N
SAN FRANCISCO
pc/m³: N,N,N,1,2,2
LOS ANGELES
pc/m³: N,N,N---
ST. LOUIS
pc/m³: N,T,1,T,1,-
CINCINNATI
pc/m³: T,T,T,T,T,2
WASHINGTON
pc/m³: N,N,N,2,T,1
ANCHORAGE
pc/m³: 9,T,T,T,N,N
LEGEND:
T-BETWEEN 0.1 AND 1 pc/m³
N-LESS THAN 0.1 pc/m³
VALUES REFER TO 6 CONSECUTIVE DAILY AIR FILTERS; SAMPLING BEGAN OCT. 21, 1964, 10 am

FIGURE 1. RECENTLY FORMED FALLOUT ON AIRBORNE PARTICLES NASN STATIONS AND RHRA CINCINNATI STATION, USING GLASS FIBER FILTERS WITH AIR VOLUME OF APPROXIMATELY 2000 m³/day.

Figures 1 and 2 show the gross beta concentrations of recently formed radionuclides on airborne particles. To correct for the gross beta activity from older fission products, their average concentration during this time, 0.5 pc/m³, was subtracted from the total concentration. The concentration of older fission products before October 16 varied between <0.1 and 1.0 pc/m³, so that the larger values, rounded to the nearest integer, provide a fair indication of relative concentration. Below a concention of 1 pc/m³ for recently formed radionuclides, the value obtained by this subtraction obviously is quite approximate; the presence of fresh fallout, as shown by gamma spectral analysis, is indicated by "T" for "trace." When recently formed fallout was below 0.1 pc/m³, corresponding to approximately 0.01 pc/m³ of Ba^{140} or Te^{132}, it could not be detected, as indicated by "N" in figures 1 and 2.

All of the radionuclide concentrations are given as measured 4 to 12 days after collection. In view of the Way-Wigner $t^{-1.2}$ decay relationship (*1*), where the time between radionuclide formation and counting, t, was 9 to 24 days, the activity on the day of collection would have been appreciably higher. Decay corrections to the day of collection lead to computed values that are as much as twice those listed.

Figures 1 and 2 show that most sampling stations in the United States received at least a trace of the fallout from the Chinese nuclear test. The highest measured gross beta radioactivity concentrations in air were at Bismarck on October 24-25, Helena on October 23-24, and Orlando on October 27-28. The respective values were 24, 21, and 18 pc/m³ on the day of counting, corresponding to 38, 36, and 28 pc/m³ on the day of collection according to the $t^{-1.2}$ decay correction.

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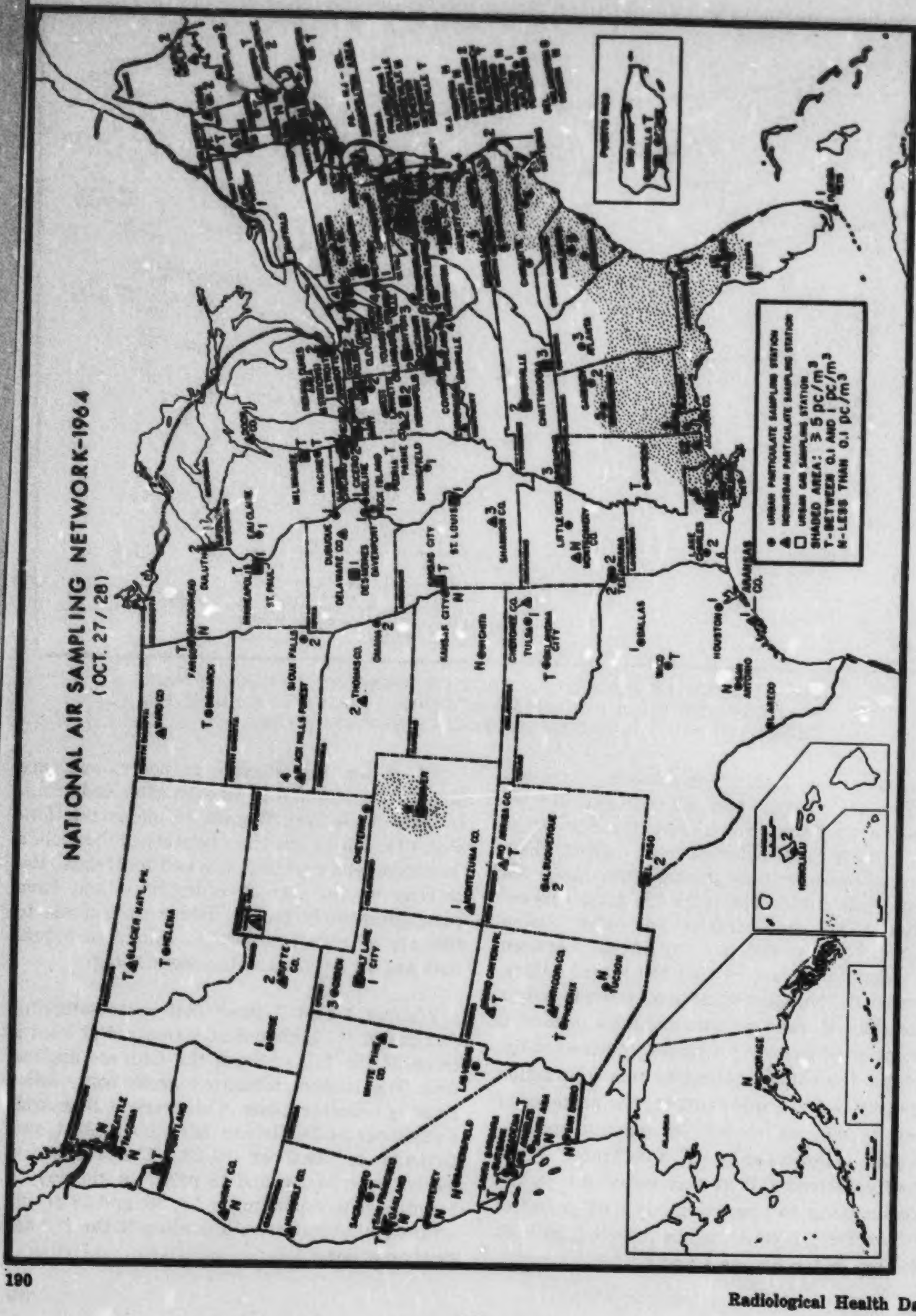
NATIONAL AIR SAMPLING NETWORK-1964
(OCT. 27/28)
URBAN PARTICULATE SAMPLING STATION
NONURBAN PARTICULATE SAMPLING STATION
URBAN GAS SAMPLING STATION
SHADED AREA: ≥ 5 pc/m³
T-BETWEEN 0.1 AND 1 pc/m³
N-LESS THAN 0.1 pc/m³
PUERTO RICO
SAN JUAN
HONOLULU
ANCHORAGE
SEATTLE
PORTLAND
HELENA
SALT LAKE CITY
CHEYENNE
DENVER
EL PASO
PHOENIX
TUCSON
LAS VEGAS
SAN FRANCISCO
LOS ANGELES
SAN DIEGO
BISMARCK
SIOUX FALLS
OMAHA
KANSAS CITY
OKLAHOMA CITY
TULSA
DALLAS
HOUSTON
SAN ANTONIO
MINNEAPOLIS
ST. PAUL
DULUTH
DES MOINES
ST. LOUIS
LITTLE ROCK
CHICAGO
DETROIT
CLEVELAND
ATLANTA
NEW ORLEANS

FIGURE 2. RECENTLY FORMED FALLOUT ON AIRBORNE PARTICLES

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The relative magnitude of the fallout concentrations in ground-level air may be considered from the following very brief description of atmospheric processes that are usually thought to be important. For a tower burst of a low-yield bomb, the bulk of the fallout is expected to occur locally. Of that which remains airborne for more than a day, most is expected to be composed of very small particles with negligible settling rates. These particles will be located in the upper troposphere where they will be transported horizontally by the winds. Figure 3, provided by the Atmospheric Radioactivity Research Branch of the U.S. Weather Bureau, shows the estimated trajectory of explosion debris at about 30,000 feet, near the top of the troposphere. The trajectory is shown to be quite wide to allow for uncertainties in the data and to depict some lateral spread of the cloud.

The most effective mechanisms to bring high-level debris to the surface are vertical mixing and precipitation. The extent of vertical mixing in the atmosphere is often difficult to determine and occurs on various scales and at varying elevations. Precipitation, especially the deep convective type, is indicative of extensive vertical mixing. If precipitation elements fall through or originate at the level of the debris, these elements are likely to capture debris particles and carry them to the surface. Another effect of precipitation may be to "drag" debris air down to the surface, thereby increasing debris concentrations in surface air as well as in surface precipitation samples. As high-level debris is mixed downward it is subjected to variable horizontal winds at lower levels, which enhance horizontal mixing.

According to the trajectory of figure 3, the debris was over Anchorage and Helena on

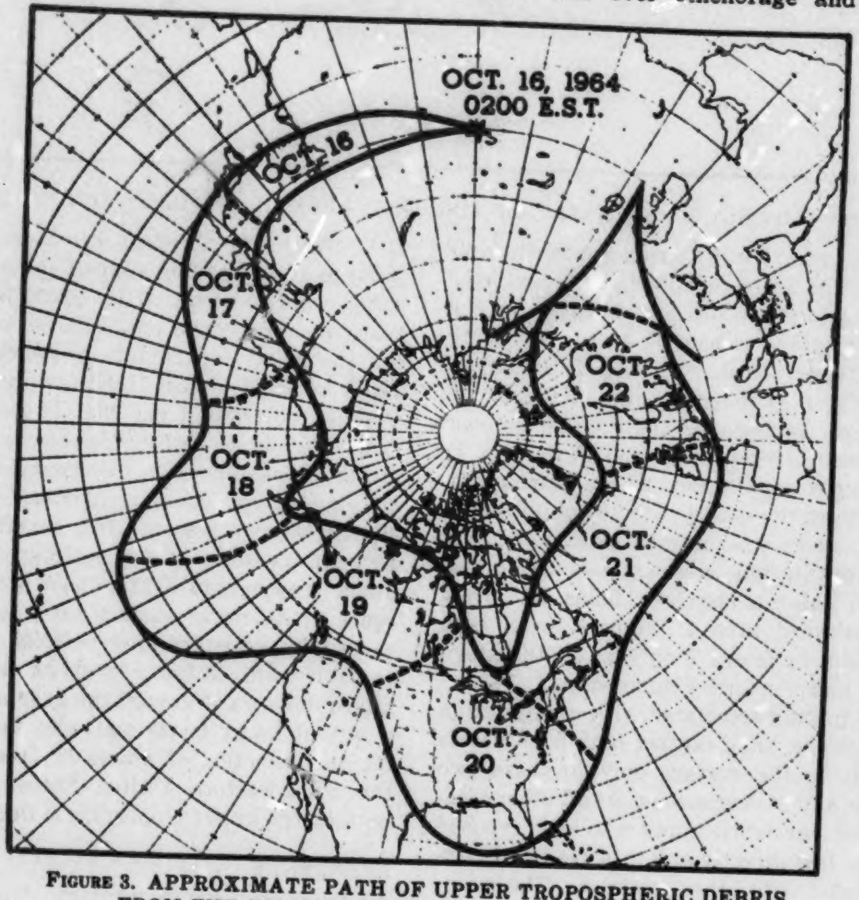

FIGURE 3. APPROXIMATE PATH OF UPPER TROPOSPHERIC DEBRIS FROM THE FIRST CHINESE NUCLEAR DETONATION

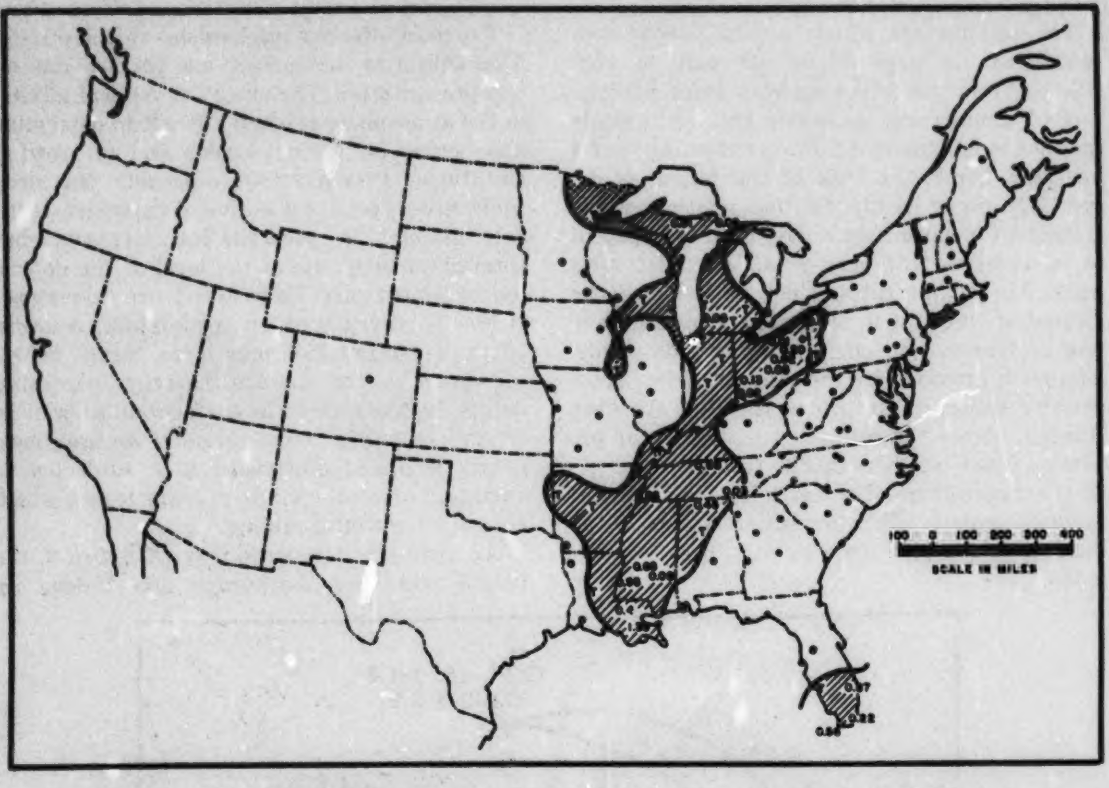

FIGURE 4. 24-HOUR PRECIPITATION (INCHES), FROM 11 AM (LST), OCT. 27, 1964

October 19, over the Central, Southern, and Eastern United States on October 20, and over the Northeastern United States early on the 21st. Precipitation measured at the sampling stations between October 21 and 27 amounted to 0.73 inch on October 21 and 0.16 inch on October 27 at Anchorage; 0.04 inch on October 27 at Portland, Oregon; 0.03 inch on October 21 and 0.01 inch on October 22 at Burlington. Figure 4 shows the total precipitation in inches for the gross beta measurement period of figure 2. The precipitation area extends along the Mississippi Valley to the Great Lakes, and overlaps the stippled area of highest gross beta concentration in figure 2 only in southeastern Louisiana and western Pennsylvania.

Vertical mixing associated with precipitation could, therefore, have carried high-level debris air directly to the surface only in these two small areas and at Anchorage. At all other locations the nuclear debris appears to have reached the surface less directly and as a result of mixing associated with other processes. The maximum radionuclide concentrations at Helena, Montana; Bismarck, North Dakota; and Duluth, Minnesota, all occur 4 to 5 days after the passage of the leading edge of the upper tropospheric debris cloud. Daily gross beta concentrations in airborne particulates, tabulated by the Radiation Surveillance Network of the Division of Radiological Health, were elevated at Denver, Colorado, since the October 24 collection. Most other high values shown in figure 2 appear to have risen to these concentrations on the day of collection, suggesting a somewhat slower rate of descent. The variable time lag between passage of the leading edge of the upper troposphere debris cloud and the occurrence of debris in surface air may have been caused by undetermined vertical mixing and variable winds at lower levels as the debris was mixed downward toward the ground. Air movements at lower levels may also be responsible for the detection of traces of fresh fallout in the Southwestern United States, out of the path of the upper tropospheric debris.

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Section II—Milk and Food

MILK SURVEILLANCE

Although milk is only one of the many sources of dietary intake of radionuclides, it is the single food item most often used as an indicator of the population's intake of radionuclides from the environment. This is because fresh milk is consumed by a large segment of the United States population and contains most of the radionuclides occurring in the environment which have been identified as biologically important. In addition, milk is produced and consumed on a regular basis, is convenient to handle, is easily analyzed, and samples which are representative of milk consumption in any area can be readily obtained.

1. Pasteurized Milk Network, December and Annual Summary for 1964

Division of Radiological Health and Division of Environmental Engineering and Food Protection, Public Health Service

The Public Health Service pasteurized milk surveillance program had its origin in a raw milk monitoring network (*1*) established by the Service in 1957. One of the primary objectives of the raw milk network was the development of methods for milk collection and radiochemical analysis suitable for larger scale programs.

Experience derived from this earlier network led to the activation of a pasteurized milk sampling program with stations selected to provide nationwide surveillance of milk production and consumption areas. The present network consists of 63 stations, with at least one in every State, the Canal Zone, and Puerto Rico.

Sampling Procedure

Through the cooperation of State and local milk sanitation authorities, samples are routinely collected at each station. The method specifies that each station's sample be composited of subsamples from each milk processing plant in proportion to the plant's average sales in the community served. At most stations the sample represents from 80 to 100 percent of the milk processed. Prior to September 15, 1961, the composite sample was taken from one day's sales per month and was as representative of the community's supply as could be achieved under practical conditions. Beginning with the resumption of nuclear weapons testing in the atmosphere in September 1961, and continuing through January 1963, samples were collected twice a week at nearly all stations and daily for short periods at selected stations. Since then, the sampling frequency has been reduced to once a week.

Samples are preserved with formaldehyde and sent to the PHS Southwestern (SWRHL), Southeastern (SERHL), or Northeastern Radiological Health Laboratories (NEHRL) for analysis. Gamma analyses for iodine-131 are made within 3 to 6 days after sample collection, and any results exceeding 100 pc/liter are immediately telephoned to State health officials for possible public health action. Analytical results are normally available 6 to 7 weeks after weekly samples are received by the laboratories; publication in *RHD* follows 3 to 4 months after the monthly samples are composited for analyses.

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Analytical Procedures

Iodine-131, cesium-137, and barium-140 concentrations are determined by gamma scintillation spectroscopy.[1] After the weekly samples are gamma scanned, samples from two consecutive weeks are composited and analyzed radiochemically for strontium-89 and strontium-90. There is an inherent statistical variation associated with all measurements of radionuclide concentrations. With the low radionuclide levels which are usually found in milk and other environmental samples, this variation on a percentage basis is relatively high. The variation depends upon such factors as the method of chemical analysis, the sample counting rate and counting time, interferences from other radionuclides, and the background count. For milk samples, counting times of 50 minutes for gamma spectroscopy and 30 to 50 minutes for beta determinations are used. Table 1 shows the approximate total analytical error (including counting error) associated with radionuclide concentrations in milk. These errors were determined by comparing results of a large number of replicate analyses.

TABLE 1.—ANALYTICAL ERRORS ASSOCIATED WITH ESTIMATED CONCENTRATIONS FOR SELECTED RADIONUCLIDES IN MILK

Nuclide	Estimated concentration (pc/liter)	Error [a] (pc/liter)	Estimated concentration (pc/liter)	Error [a] (percent of concentration)
Iodine-131	0 to 100	±10	100 or greater	±10
Barium-140	0 to 100	±10	100 or greater	±10
Cesium-137	0 to 100	±10	100 or greater	±10
Strontium-89	0 to 50	± 5	50 or greater	±10
Strontium-90	0 to 20	± 2	20 or greater	±10

[a] Two standard deviations (2σ).

The minimum detectable concentration is defined as the measured concentration at which the two-standard-deviation analytical error is equal to the measurement. Accordingly, the minimum detectable concentrations in units of pc/liter are Sr^{89}, 5; Sr^{90}, 2; Cs^{137}, 10; Ba^{140}, 10; and I^{131}, 10. At these levels and below, the counting error comprises nearly all of the analytical error.

Calcium analyses at SERHL are done by an ion exchange and permanganate titration method, while at NERHL and SWRHL an ethylenediaminetetraacetic acid (EDTA) method is used. Stable potassium concentrations are estimated from the potassium-40 concentrations[2] determined from the gamma spectrum.

Data Presentation

Table 2 presents summaries of the analyses for December (actual reporting period November 29-December 26) and fourth quarter 1964. Radionuclide values reported by a laboratory as being below the minimum detectable concentration have been averagd by using one-half the minimum detectable value. The averaging procedure was modified for iodine-131 and barium-140 in October 1963 when nondetectable concentrations of these radionuclides were considered zero. A similar procedure is used for the network average.

Figures 1 and 2 are isogram maps showing the estimated strontium-90 and cesium-137 concentrations in milk over the entire country. The value printed beside each station is the monthly average concentration for that station. The isograms were developed by arbitrary interpolation between values for the individual stations. Additional modifications to the isograms are made according to available information on milksheds.

In tables 3 and 4, the distribution of the network's stations *versus* radionuclide concentrations in milk for the last 6 months are compared.

For special purposes of comparison and reference, the Network maximum, minimum, and average monthly radionuclide concentrations for the early years of operation (March 1960-March 1964) were summarized in tabular form in the July 1964 *RHD* (*2*).

The average monthly strontium-90 concentrations in pasteurized milk from selected cities in the sampling program are presented in figure 3. Each graph shows the strontium-90 concentrations in milk from one city in each of the four U.S. Bureau of Census regions. This method of selection permits graphic presentation of data for each city in the network three times a year.

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[1] Southeastern Radiological Health Laboratory employs a radiochemical procedure for barium-140 analysis.

[2] The conversion factor is 1.18 x 10^{-3} g K/pc K^{40}.

TABLE 2.—STABLE ELEMENT AND RADIONUCLIDE CONCENTRATIONS IN PASTEURIZED MILK, DECEMBER 1964 AND FOURTH QUARTER 1964

Sampling locations		Calcium (g/liter)		Strontium-89 (pc/liter)		Strontium-90 (pc/liter)		Cesium-137 (pc/liter)		Iodine-131 (pc/liter)		Barium-140 (pc/liter)	
		Fourth quarter	Avg. for month	Fourth quarter	Avg. for month	Fourth quarter	Avg. for month	Fourth quarter	Avg. for month	Fourth quarter	Avg. for month	Fourth quarter	Avg. for month
Ala:	Montgomery	1.20	1.24	<5	<5	19	20	60	55	0	0	0	0
Alaska:	Palmer	1.22	1.20	<5	<5	19	20	60	60	0	0	0	0
Ariz:	Phoenix	1.19	1.18	<5	<5	4	4	25	50	0	0	0	0
Ark:	Little Rock	1.17	1.18	<5	<5	23	22	60	60	0	0	0	0
Calif:	Sacramento	1.20	1.20	<5	<5	5	4	35	50	0	10	0	0
	San Francisco	1.22	1.24	<5	<5	8	8	50	50	0	0	0	0
C. Z:	Cristobal	1.14	1.16	<5	<5	5	6	50	45	0	0	0	0
Colo:	Denver	1.29	1.28	<5	<5	16	17	55	90	0	0	0	0
Conn:	Hartford	1.13	1.11	<5	<5	14	15	85	80	0	0	0	0
Del:	Wilmington	1.17	1.15	<5	<5	15	17	70	70	0	0	0	0
D. C:	Washington	1.15	1.19	<5	<5	17	16	45	80	0	0	0	0
Fla:	Tampa	1.18	1.20	<5	<5	15	14	210	190	0	0	0	0
Ga:	Atlanta	1.20	1.22	<5	<5	24	24	85	80	0	0	0	0
Hawaii:	Honolulu	1.20	1.18	5	<5	13	9	70	75	0	0	0	0
Idaho:	Idaho Falls	1.23	1.24	<5	<5	19	22	80	100	0	0	0	0
Ill:	Chicago	1.16	1.14	<5	<5	16	17	75	80	0	0	0	0
Ind:	Indianapolis	1.20	1.19	<5	<5	15	15	60	70	0	0	0	0
Iowa:	Des Moines	1.22	1.19	<5	<5	21	21	55	85	0	0	0	0
Kans:	Wichita	1.26	1.26	<5	<5	17	17	60	80	0	0	0	0
Ky:	Louisville	1.18	1.20	<5	<5	23	22	45	80	0	0	0	0
La:	New Orleans	1.23	1.24	10	10	40	40	75	70	0	0	0	0
Maine:	Portland	1.16	1.15	<5	<5	24	24	145	160	0	0	0	0
Md:	Baltimore	1.16	1.19	<5	<5	16	16	50	55	0	0	0	0
Mass:	Boston	1.15	1.14	<5	<5	23	21	125	135	0	0	0	0
Mich:	Detroit	1.17	1.14	<5	<5	15	14	75	75	10	0	0	0
	Grand Rapids	1.20	1.16	<5	<5	19	16	85	85	0	0	0	0
Minn:	Minneapolis	1.24	1.24	5	<5	24	24	60	90	0	0	0	0
Miss:	Jackson	1.23	1.27	<5	5	22	22	60	80	0	0	0	0
Mo:	Kansas City	1.22	1.22	<5	<5	21	20	60	45	0	0	0	0
	St. Louis	1.24	1.25	<5	<5	16	18	45	50	0	0	0	0
Mont:	Helena	1.25	1.23	<5	<5	16	17	55	50	0	0	0	0
Nebr:	Omaha	1.19	1.21	<5	<5	17	15	45	90	0	0	0	0
Nev:	Las Vegas	1.24	1.20	<5	<5	8	7	60	60	0	0	0	0
N. H:	Manchester	1.18	1.16	<5	<5	22	23	155	165	0	0	0	0
N. J:	Trenton	1.12	1.11	<5	<5	15	14	70	60	0	0	0	0
N. Mex:	Albuquerque	1.23	1.20	<5	<5	9	9	65	50	0	0	0	0
N. Y:	Buffalo	1.11	1.10	<5	<5	16	18	90	100	0	0	0	0
	New York	1.15	1.10	<5	<5	19	18	95	105	0	0	0	0
	Syracuse	1.12	1.12	<5	<5	15	15	90	100	0	0	0	0
N. C:	Charlotte	1.21	1.24	<5	<5	23	24	65	65	0	0	0	0
N. Dak:	Minot	1.19	1.16	<5	<5	38	40	110	130	0	0	0	0
Ohio:	Cincinnati	1.19	1.18	<5	<5	17	17	90	95	0	0	0	0
	Cleveland	1.17	1.12	<5	<5	18	18	75	85	0	0	0	0
Okla:	Oklahoma City	1.18	1.24	5	<5	18	19	45	45	0	0	0	0
Ore:	Portland	1.20	1.20	<5	<5	22	22	50	100	0	0	0	0
Pa:	Philadelphia	1.18	1.16	<5	<5	19	16	85	85	0	0	0	0
	Pittsburgh	1.16	1.16	<5	<5	24	25	85	100	0	0	0	0
P. R:	San Juan	1.14	1.16	<5	<5	10	10	50	50	0	0	0	0
R. I:	Providence	1.17	1.15	<5	<5	18	17	95	100	0	0	0	0
S. C:	Charleston	1.17	1.20	<5	5	29	28	90	130	0	0	0	0
S. Dak:	Rapid City	1.08	1.02	<5	<5	27	22	115	130	0	0	0	0
Tenn:	Chattanooga	1.20	1.22	5	5	21	20	65	60	0	0	0	0
	Memphis	1.20	1.24	<5	<5	25	24	45	50	0	0	0	0
Tex:	Austin	1.14	1.14	<5	<5	7	6	25	25	0	0	0	0
	Dallas	1.18	1.20	<5	<5	15	16	35	40	0	0	0	0
Utah:	Salt Lake City	1.34	1.28	<5	<5	18	21	60	110	0	0	0	0
Vt:	Burlington	1.16	1.12	<5	<5	20	19	105	115	10	0	0	0
Va:	Norfolk	1.19	1.20	<5	<5	21	22	60	80	0	0	0	0
Wash:	Seattle	1.24	1.28	<5	<5	20	20	95	90	0	0	0	0
	Spokane	1.20	1.30	<5	<5	22	23	95	110	0	0	0	0
W. Va:	Charleston	1.16	1.20	<5	<5	17	16	40	40	0	0	0	0
Wis:	Milwaukee	1.22	1.18	<5	<5	14	14	85	90	0	0	0	0
Wyo:	Laramie	1.22	1.22	<5	<5	15	15	70	75	0	0	0	0
Network average		1.19	1.20	<5	<5	18.8	18.7	73	77	0	0	0	0

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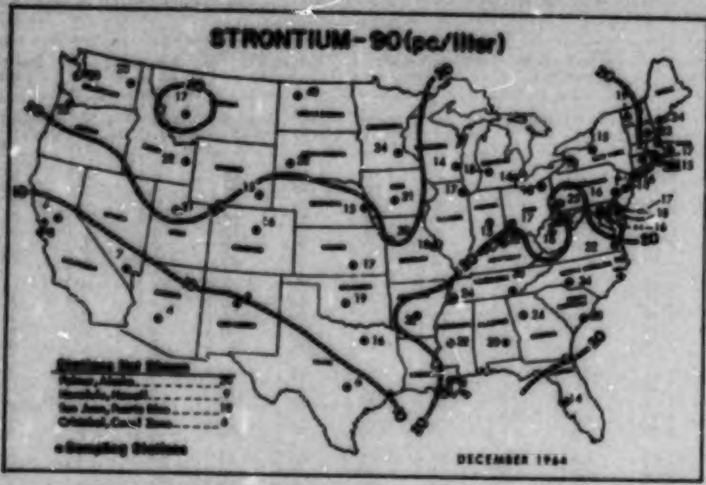
STRONTIUM-90(pc/liter)
Stations Not Shown
Palmer, Alaska
Honolulu, Hawaii
San Juan, Puerto Rico
Cristobal, Canal Zone
• Sampling Stations
DECEMBER 1964

FIGURE 1. STRONTIUM-90 CONCENTRATIONS IN PASTEURIZED MILK

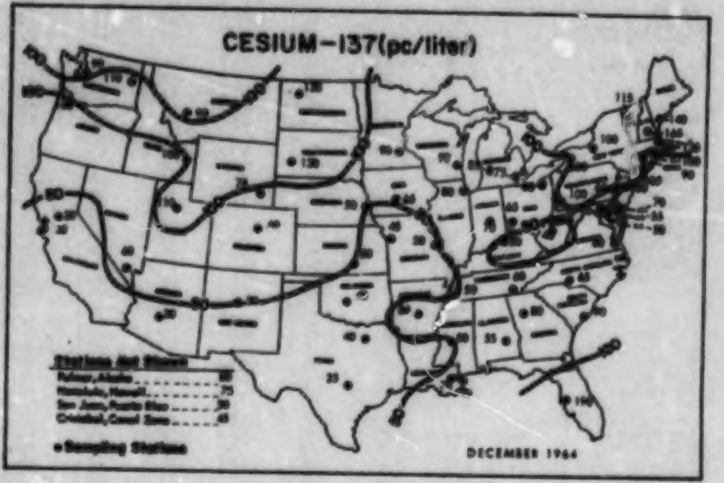
CESIUM-137(pc/liter)
Stations Not Shown
Palmer, Alaska
Honolulu, Hawaii
75
San Juan, Puerto Rico
30
Cristobal, Canal Zone
45
• Sampling Stations
DECEMBER 1964

FIGURE 2. CESIUM-137 CONCENTRATIONS IN PASTEURIZED MILK

TABLE 3.—RANGES OF STATION MONTHLY AVERAGES FOR STRONTIUM-90, JULY-DECEMBER 1964 AND DECEMBER 1963

Strontium-90 range	Number of stations in range						
	1964						1963
	July	Aug.	Sept.	Oct.	Nov.	Dec.	Dec.
Under 10 pc/l	6	7	8	6	6	8	4
10–19 pc/l	6	23	27	37	31	29	11
20–29 pc/l	20	23	20	12	19	20	23
30–39 pc/l	14	6	8	7	6	4	11
40–49 pc/l	4	4	2	3	1	2	3
50–59 pc/l	1	0	0	0	0	0	0
60–69 pc/l	2	0	0	0	0	0	1
70–79 pc/l	0	0	0	0	0	0	0

TABLE 4.—RANGES OF STATION MONTHLY AVERAGES FOR CESIUM-137, JULY-DECEMBER 1964 AND DECEMBER 1963

Cesium-137 range	Number of stations in range						
	1964						1963
	July	Aug.	Sept.	Oct.	Nov.	Dec.	Dec.
Under 50 pc/l	4	6	14	16	15	9	3
50–99 pc/l	24	30	32	40	41	38	16
100–149 pc/l	21	10	13	6	4	14	23
150–199 pc/l	8	6	2	0	2	2	14
200–249 pc/l	3	1	1	1	1	0	5
250–349 pc/l	2	1	0	0	0	0	2

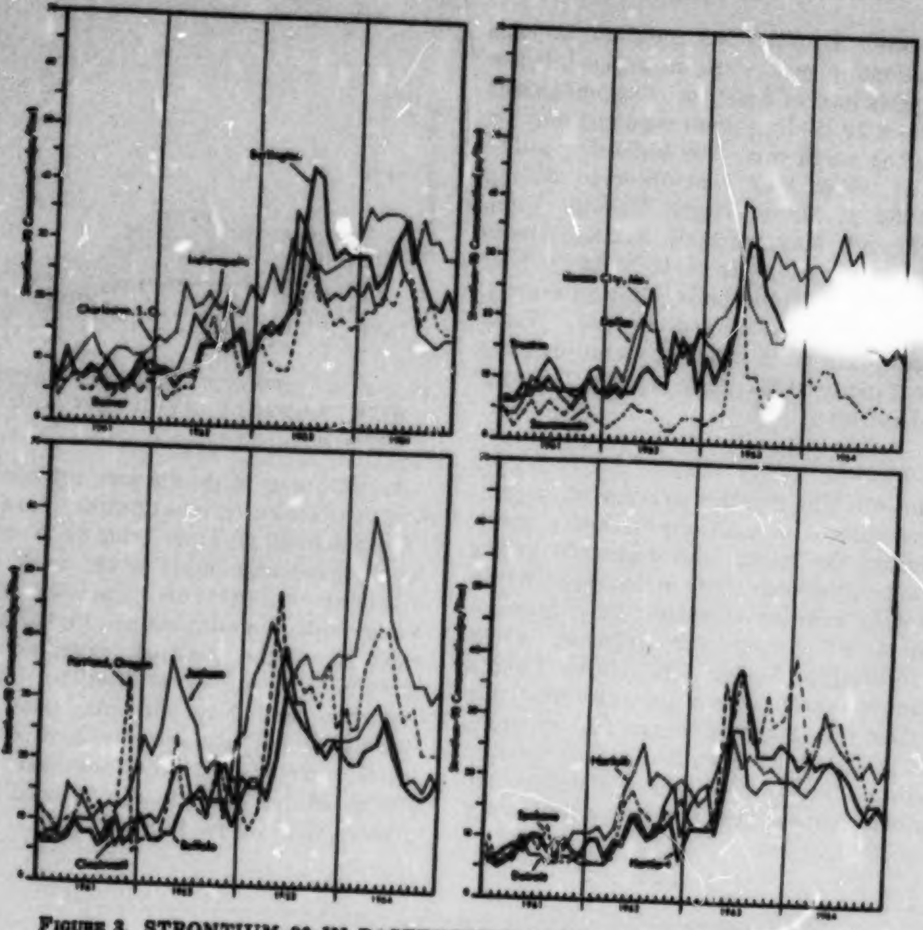

FIGURE 3. STRONTIUM-90 IN PASTEURIZED MILK, 1961–DECEMBER 1964

Summary of 1964 Network Results

With the completion of December milk analyses, it is appropriate to present an annual summary of the concentrations of stable calcium and potassium, strontium-89, strontium-90, iodine-131, cesium-137, and barium-140 for 1964.

Stable calcium and potassium: The monthly average calcium concentrations varied around an annual average of 1.18 grams per liter, with a range of 1.16 to 1.21 grams per liter. Potassium monthly average concentrations exhibited little variation around the annual average of 1.5 grams per liter. Individual monthly averages and ranges are given in table 5.

TABLE 5.—STABLE CALCIUM AND POTASSIUM IN PASTEURIZED MILK–1964

Month	Calcium (g/liter)		Potassium (g/liter)	
	Average	Range	Average	Range
January	1.21	1.15–1.30	1.6	1.4–1.7
February	1.20	1.11–1.26	1.6	1.5–1.7
March	1.19	1.11–1.28	1.5	1.4–1.8
April	1.18	1.01–1.30	1.5	1.3–1.6
May	1.18	1.09–1.29	1.5	1.4–1.6
June	1.17	1.12–1.27	1.5	1.4–1.6
July	1.17	1.10–1.28	1.5	1.4–1.6
August	1.17	1.08–1.31	1.5	1.2–1.7
September	1.16	1.03–1.30	1.5	1.2–1.6
October	1.18	0.98–1.41	1.5	1.3–1.6
November	1.21	1.10–1.34	1.5	1.3–1.6
December	1.20	1.02–1.38	1.5	1.4–1.8
Annual	1.18	0.98–1.41	1.5	1.2–1.8

Strontium-89: Strontium-89 monthly average concentrations in milk were, in general, below the detectable level of 5 pc/liter. Concentrations greater than 10 pc/liter were reported only by States in the northwest. The highest monthly average of 30 pc/liter was observed during March 1964 at Minot, North Dakota. From March through May, monthly average strontium-89 concentrations from 10 to 20 pc/liter were observed in Minneapolis, Minn., Laramie, Wyo., Spokane, Wash, and Seattle, Wash. These values are of an order of magnitude less than the January 1962 peak value of 200 pc/liter in Louisiana.

Strontium-90: The monthly average strontium-90 concentrations in milk approached a maximum during the spring and decreased in the fall to values less than those in January (figure 4). Monthly average strontium-90 concentrations up to 69 pc/liter were reported in the lower Mississippi Valley. The North Dakota strontium-90 concentrations were also relatively higher than the network average (for example, 77 pc/liter was observed in May). This trend in the Dakotas, the lower Mississippi Valley, and the southern Appalachian States was previously noted in 1962 (*3*).

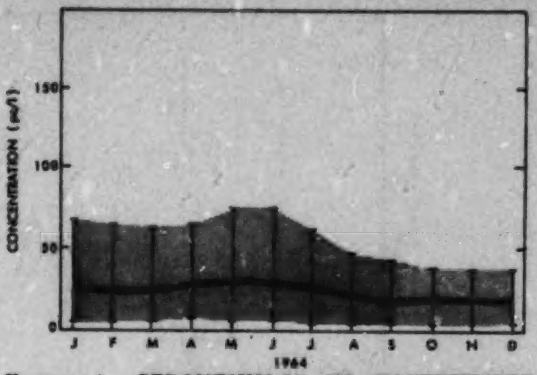

FIGURE 4. STRONTIUM-90 IN PASTEURIZED MILK, MONTHLY AVERAGES AND RANGES FOR 1964

In 1964 most of the stations reported average *monthly* concentrations of strontium-90 in milk of less than 30 pc/liter (table 6). North Dakota had consistently high levels with a *weekly* maximum of 84 pc/liter. The lower Mississippi Valley also had consistently higher concentrations than the network average, including *weekly* highs of 71 pc/liter in Little Rock, Arkansas and New Orleans, Louisiana. The Southwest had consistently low strontium-90 levels (<20 pc/liter). The Southeast and Great Plains States sporadically showed values of greater than 30 pc/liter.

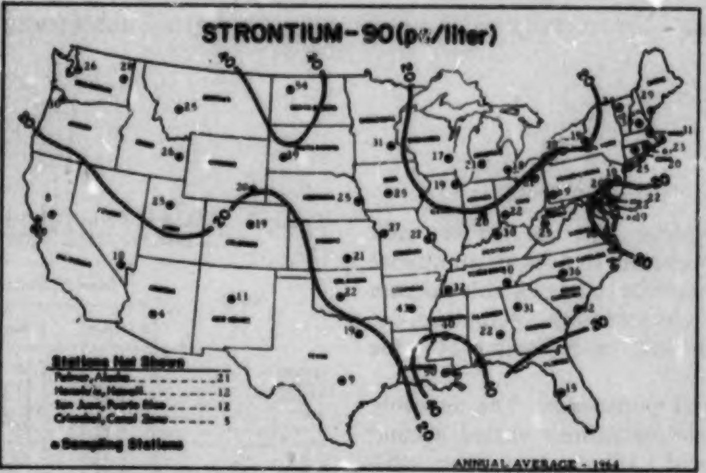

FIGURE 5. STRONTIUM-90 CONCENTRATIONS IN PASTEURIZED MILK

TABLE 6. STRONTIUM-90 IN PASTEURIZED MILK, 1964 (pc/liter)

Sampling location		Jan	Feb	Mar	1st qtr	Apr	May	Jun	2nd qtr	Jul	Aug	Sept	3rd qtr	Oct	Nov	Dec	4th qtr	Annual
Ala:	Montgomery	22	24	25	24	26	30	23	26	21	22	19	21	18	20	20	19	22
Alaska:	Palmer	27	23	18	23	20	28	28	25	20	13	16	16	19	19	20	19	21
Ariz:	Phoenix	4	5	4	4	8	5	5	6	3	4	3	3	5	4	4	4	4
Ark:	Little Rock	39	41	50	43	56	69	40	58	40	39	34	38	34	33	32	33	43
Calif:	Sacramento	11	9	12	11	12	8	8	9	7	5	7	6	6	6	4	5	8
	San Francisco	11	13	14	13	16	11	8	12	8	9	4	7	11	4	8	8	10
Canal Zone:	Cristobal	6	6	6	6	6	6	6	6	4	4	6	5	5	5	6	5	5
Colo:	Denver	18	19	19	19	21	20	26	22	24	17	20	20	17	16	16	16	19
Conn:	Hartford	24	22	24	23	22	23	23	23	22	20	16	19	14	14	15	14	20
Del:	Wilmington	22	19	22	21	28	34	28	30	23	19	18	20	14	16	17	16	22
D. C:	Washington	18	17	18	18	21	25	24	23	22	18	16	19	18	17	16	17	19
Fla:	Tampa	14	16	14	15	17	15	14	15	17	15	18	17	16	14	14	15	15
Ga:	Atlanta	30	38	36	35	37	41	30	36	29	29	26	28	24	25	24	24	31
Hawaii:	Honolulu	9	12	11	11	12	10	11	11	10	15	8	11	15	15	9	13	12
Idaho:	Idaho Falls	31	30	10	27	40	30	33	34	30	26	18	25	14	21	22	19	26
Ill:	Chicago	21	21	20	21	18	17	23	19	22	20	14	19	15	16	17	16	19
Ind:	Indianapolis	22	24	20	22	20	30	25	25	23	16	15	18	14	15	15	15	20
Iowa:	Des Moines	27	27	26	27	27	34	28	30	27	30	20	22	19	23	21	21	25
Kans:	Wichita	22	24	24	23	18	28	30	25	21	16	17	18	16	19	17	17	21
Ky:	Louisville	31	31	34	32	37	37	36	37	31	27	23	27	22	24	23	23	30
La:	New Orleans	48	49	64	54	66	59	53	50	52	40	43	48	39	40	40	40	50
Maine:	Portland	32	32	30	31	30	34	35	33	36	26	25	29	23	26	24	24	29
Md:	Baltimore	19	20	22	20	22	30	31	28	26	20	18	21	18	19	18	18	22
Mass:	Boston	35	34	28	32	32	39	43	36	41	30	22	31	21	23	21	22	31
Mich:	Detroit	20	19	18	19	19	22	23	21	21	15	13	16	16	16	15	14	18
	Grand Rapids	23	23	19	22	19	24	26	23	23	18	15	19	18	20	18	19	21
Minn:	Minneapolis	38	38	30	35	30	30	42	37	34	26	22	27	24	23	24	24	31
Miss:	Jackson	37	38	48	41	60	54	44	53	40	38	33	37	33	30	32	32	40
Mo:	Kansas City	29	29	27	28	30	35	30	32	32	24	22	26	21	21	30	21	27
	St. Louis	22	23	24	23	26	30	28	28	29	17	16	21	17	18	18	18	22
Mont:	Helena	28	33	31	31	29	24	32	32	27	19	15	20	15	15	17	16	25
Nebr:	Omaha	23	26	26	25	28	32	31	30	30	22	21	24	19	18	15	17	25
Nev:	Las Vegas	19	14	13	15	6	13	10	10	8	7	4	6	7	10	7	8	10
N. H:	Manchester	35	34	28	32	30	34	36	33	36	28	26	30	23	22	23	23	30
N. J:	Trenton	20	17	18	18	18	25	25	23	23	16	16	18	14	17	14	15	19
N. Mex:	Albuquerque	11	14	11	12	17	12	14	14	12	7	8	9	9	9	9	9	11
N. Y:	Buffalo	21	20	20	20	22	23	28	24	22	17	15	18	14	16	18	16	20
	New York	28	26	22	25	25	28	36	30	32	23	19	25	18	22	18	19	25
	Syracuse	23	22	20	22	21	24	23	23	NS	15	15	15	15	16	15	15	19
N. C:	Charlotte	30	28	36	31	37	46	47	43	39	39	36	38	34	30	34	33	36
N. Dak:	Minot	68	67	39	58	62	77	76	72	63	44	40	49	39	35	40	38	54
Ohio:	Cincinnatti	24	24	25	24	27	30	26	28	21	17	18	19	16	19	17	17	22
	Cleveland	22	20	23	22	19	24	31	25	23	18	16	19	17	18	18	18	21
Okla:	Oklahoma City	22	27	26	25	27	29	26	27	20	18	18	19	17	18	19	18	22
Ore:	Portland	29	26	26	27	36	43	42	40	33	28	30	30	22	23	22	22	30
Pa:	Philadelphia	20	19	20	20	22	28	26	25	21	17	16	18	15	16	16	16	20
	Pittsburg	30	27	28	28	28	34	40	34	35	29	24	29	21	25	25	24	29
P. R:	San Juan	11	12	13	12	16	14	14	15	14	10	12	12	11	10	10	10	12
R. I:	Providence	26	24	25	25	24	27	30	27	25	21	22	23	19	18	17	18	23
S. C:	Charleston	33	36	34	34	35	35	34	35	27	34	31	31	31	28	28	29	32
S. Dak:	Rapid City	40	45	30	38	35	52	58	48	62	40	27	43	28	32	22	27	39
Tenn:	Chattanooga	35	35	44	38	54	52	46	51	42	40	36	39	33	31	30	31	40
	Memphis	28	32	36	32	42	43	40	42	32	31	22	28	27	23	24	25	32
Tex:	Austin	8	11	11	10	9	10	10	10	8	8	6	7	7	8	6	7	9
	Dallas	21	21	24	22	22	24	21	22	18	17	16	17	14	15	16	15	19
Utah:	Salt Lake City	28	28	26	27	32	29	29	30	28	23	24	25	18	14	21	18	25
Vt:	Burlington	28	28	23	26	25	30	34	30	29	25	20	25	19	23	19	20	25
Va:	Norfolk	20	19	22	20	24	31	28	28	25	24	20	23	23	19	22	21	18
Wash:	Seattle	20	20	24	21	24	44	40	36	35	28	22	28	16	24	20	20	26
	Spokane	40	35	24	33	27	29	30	29	30	24	24	26	23	21	23	22	28
W. Va:	Charleston	25	26	28	26	28	40	34	34	26	24	21	24	19	17	16	17	25
Wis:	Milwaukee	21	19	18	19	21	20	21	21	17	14	12	14	14	15	14	14	17
Wyo:	Laramie	19	24	19	21	22	25	29	25	28	18	14	20	14	15	15	15	20
Network average		24.9	25.3	24.3	24.8	26.8	30.3	29.5	28.9	26.3	21.6	19.3	22.3	18.7	19.1	18.7	18.8	23.7
Maximum		68	67	64	58	66	77	76	72	63	49	43	49	39	40	40	40	54
Minimum		4	5	4	4	6	5	5	6	3	4	3	3	5	4	4	4	4

Iodine-131: From January through October 1964 the monthly average iodine-131 concentrations in milk were below detectable limits (10 pc/liter) throughout the country. Following the Mainland China nuclear test of October 16, 1964 an increase of iodine-131 in milk was observed at 29 stations from October 26 to November 23, 1964. The increase was of such a limited nature that only 12 stations exhibited monthly averages greater than the detection

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limit. The highest individual value was 60 pc/liter as observed in Albuquerque, New Mexico on October 26, 1964. Iodine-131 was not observed at sampling stations in the South and Southeast. For those stations where increases were observed, the individual sample results are shown in table 7: Since November 23, 1964, levels of iodine-131 in milk have remained below the detectable limit of 10 pc/liter.

TABLE 7.—OCCURRENCE OF IODINE-131 IN PASTURIZED MILK, 1964

[Concentration in pc/liter]

		October						November																							
		26	27	28	29	30	31	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Colo:	Denver	*		20								*																			
Del:	Wilmington											20								*											
Idaho:	Idaho Falls	20									*																				
Ill:	Chicago										10																				
Ind:	Indianapolis								20															*							
Maine:	Portland		10							20							*							10							
Mass:	Boston									10							*														
Mich:	Detroit		50						30								10						*								
	Grand Rapids	20							20							30							*								
Minn:	Minneapolis		20							*																					
Miss:	Jackson																						*							20	
Mont:	Helena	*		30							*																				
Nev:	Las Vegas				30							NS																			
N. H:	Manchester										20						*							10							
N. J:	Trenton		10							30							*							10							
N. Mex:	Alburquerque	60								*																					
N. Y:	Buffalo				20	20							10							*											
	New York								30							10							*								
	Syracuse			20							10						*														
N. Dak:	Minot								20							*			*												*
Ohio:	Cincinnati										10														10						
	Cleveland					20							*																		
Okla:	Oklahoma City									*						*								20						*	
Pa:	Philadelphia					10							*																		
	Pittsburgh	10							20							*				10											
R. I:	Providence					20							*																		
Texas:	Austin												*							10							*				
Vt:	Burlington		40							30							*							10							
Va:	Norfolk									*										20							*				
Wis:	Milwaukee		20							20							*							30							*

* Less than detectable.
NS—No sample collected.

Cesium-137: The network monthly average cesium-137 concentrations were observed to decrease as the year passed (table 8). The monthly average values and ranges are shown in figure 6. The general trend indicates a decrease in concentration progressing from north to south. Variation on this trend is observed in the southeast where Florida consistently exhibits higher values than its neighbors. This suggests the presence of a dairy food supply indigenous to that area as the source of cesium-137. Geographical variation in average annual cesium-137 concentrations is observed in figure 7.

Most of the stations exhibited annual average concentrations of cesium-137 in milk of less than 150 pc/liter except for the northwest, northeast, and Florida. In general, levels were observed to decrease steadily throughout the year particularly in 1963. This is seen when

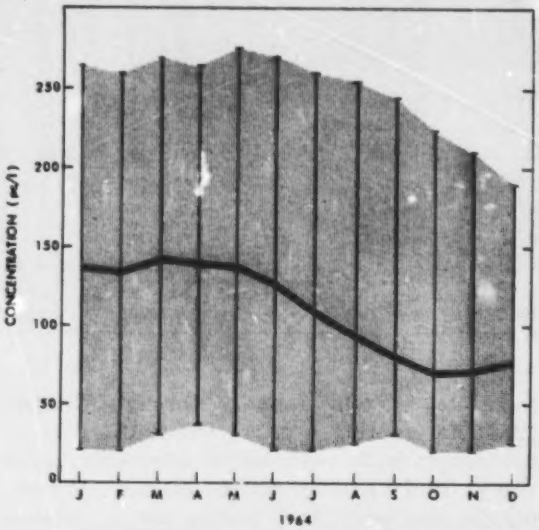

FIGURE 6. CESIUM-137 IN PASTEURIZED MILK, MONTHLY AVERAGES AND RANGES, 1964

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TABLE 8.—CESIUM-137 IN PASTEURIZED MILK—1964, (pc/liter)

Sampling location		Jan	Feb	Mar	1st qtr	Apr	May	Jun	2nd qtr	Jul	Aug	Sept	3rd qtr	Oct	Nov	Dec	4th qtr	Annual
Ala:	Montgomery	95	105	95	100	95	100	80	90	70	70	60	65	60	60	55	60	79
Alaska:	Palmer	170	165	140	160	155	155	140	150	110	100	100	105	85	80	80	80	124
Ariz:	Phoenix	20	20	30	25	35	30	20	30	20	25	20	25	20	20	30	25	25
Ark:	Little Rock	150	165	175	165	170	190	120	160	90	80	65	80	65	60	60	60	117
Calif:	Sacramento	80	60	70	65	60	40	55	50	35	25	20	30	20	30	30	25	42
	San Francisco	80	75	70	75	65	50	50	55	40	30	30	35	20	35	30	30	46
Canal Zone:	Cristobal	50	50	50	50	55	55	50	55	50	50	50	50	55	50	45	50	51
Colo:	Denver	80	95	100	90	95	80	100	90	120	100	85	100	75	60	60	65	88
Conn:	Hartford	180	180	190	185	175	155	155	160	130	115	90	110	75	90	90	85	135
Del:	Wilmington	145	130	160	150	155	155	130	145	110	85	65	85	65	70	70	70	113
D. C:	Washington	105	105	110	105	110	100	85	100	80	60	55	65	50	40	50	45	79
Fla:	Tampa	185	190	225	200	240	275	270	260	260	255	245	255	225	210	190	210	231
Ga:	Atlanta	145	180	180	160	180	190	130	165	120	105	90	105	90	90	80	85	130
Hawaii:	Honolulu	80	75	85	80	80	85	90	85	70	75	70	70	70	70	75	70	77
Idaho:	Idaho Falls	200	240	215	220	230	195	195	205	140	105	85	110	60	85	100	80	154
Ill:	Chicago	145	145	180	145	145	130	115	130	100	85	70	85	70	70	80	75	109
Ind:	Indianapolis	120	115	130	120	120	105	110	110	90	65	55	70	55	60	70	60	91
Iowa:	Des Moines	110	105	110	110	110	100	90	100	85	65	65	70	45	50	65	55	83
Kans:	Wichita	75	80	85	80	80	80	75	80	60	50	40	50	45	30	50	40	63
Ky:	Louisville	125	125	130	125	125	90	85	100	65	50	40	50	45	45	50	45	81
La:	New Orleans	155	155	190	165	205	195	140	180	125	115	100	115	90	70	70	75	135
Maine:	Portland	230	215	215	220	205	225	200	210	190	180	150	175	135	155	140	145	187
Md:	Baltimore	110	115	125	115	135	130	105	125	90	60	55	70	50	50	55	50	90
Mass:	Boston	265	255	270	265	255	240	240	245	210	195	140	180	105	130	135	125	203
Mich:	Detroit	140	130	135	135	130	130	105	120	110	90	70	90	70	75	75	75	105
	Grand Rapids	145	140	150	145	140	140	120	135	115	100	85	100	85	85	90	85	116
Minn:	Minneapolis	180	190	195	190	160	165	155	160	140	110	90	115	70	75	90	80	135
Miss:	Jackson	120	125	135	125	140	130	100	125	90	90	80	85	65	60	50	60	99
Mo:	Kansas City	105	100	100	100	110	95	90	100	65	50	50	55	35	40	45	40	73
	St. Louis	105	95	105	100	100	90	100	95	70	55	40	55	45	40	50	45	74
Mont:	Helena	235	230	235	235	225	205	155	195	130	100	110	115	85	85	90	85	157
Nebr:	Omaha	100	105	110	105	120	105	85	105	80	75	60	70	45	40	50	45	87
Nev:	Las Vegas	95	85	100	95	90	85	95	90	55	50	45	50	35	55	60	50	70
N. H:	Manchester	265	260	255	260	265	250	235	250	250	200	160	205	140	165	165	155	217
N. J:	Trenton	140	135	150	140	140	140	125	135	105	90	65	85	65	70	80	70	106
N. Mex:	Albuquerque	60	55	60	60	90	55	60	70	50	45	35	45	35	45	50	45	53
N. Y:	Buffalo	165	175	175	170	170	155	150	160	130	105	85	105	80	90	100	90	131
	New York	190	185	195	190	195	175	170	180	150	120	90	120	85	95	105	95	146
	Syracuse	165	165	180	170	165	165	145	160	NS	85	80	80	80	90	100	90	129
N. C:	Charlotte	110	115	120	115	125	155	135	140	110	105	80	100	70	65	65	65	105
N. Dak:	Minot	165	165	155	160	165	175	180	175	185	125	120	145	100	100	130	110	147
Ohio:	Cincinnati	130	125	120	125	120	95	100	105	70	60	45	60	50	60	65	60	86
	Cleveland	130	125	145	135	140	125	140	135	115	80	70	90	65	70	85	75	107
Okla:	Oklahoma City	85	90	90	90	80	75	75	75	60	50	45	50	45	45	45	45	65
Ore:	Portland	170	145	150	155	185	160	220	190	205	175	120	165	85	85	100	90	149
Pa:	Philadelphia	140	140	150	145	150	130	120	140	105	75	65	80	70	60	65	65	110
	Pittsburgh	160	170	175	170	180	175	175	175	160	115	90	120	80	80	100	85	138
P. R:	San Juan	55	70	85	70	100	90	75	90	80	70	65	70	55	50	50	50	70
R. I:	Providence	180	190	185	185	180	175	180	180	165	140	115	140	95	95	100	95	150
S. C:	Charleston	120	150	140	135	140	180	120	145	100	120	110	110	95	90	90	90	122
S. Dak:	Rapid City	180	170	175	175	145	155	170	155	165	105	110	125	100	110	130	115	142
Tenn:	Chattanooga	140	145	155	145	165	145	125	145	95	95	75	90	65	65	60	65	111
	Memphis	90	80	95	90	85	100	70	85	60	55	45	55	40	40	50	45	68
Tex:	Austin	40	55	45	45	40	50	50	45	25	30	45	35	20	25	25	25	38
	Dallas	80	90	85	85	70	70	65	70	50	45	40	45	30	30	40	35	58
Utah:	Salt Lake City	200	210	235	215	225	185	170	195	180	175	140	165	90	65	110	90	165
Vt:	Burlington	220	205	210	210	210	195	170	190	150	155	120	140	90	110	115	105	162
Va:	Norfolk	100	105	110	105	105	125	105	110	90	70	70	75	65	55	60	60	88
Wash:	Seattle	120	115	125	120	140	170	265	190	220	170	125	170	105	90	90	95	144
	Spokane	155	145	140	145	165	155	150	155	140	130	115	130	85	95	110	95	132
W. Va:	Charleston	105	110	110	110	105	95	80	95	60	55	35	50	40	40	40	40	73
Wis:	Milwaukee	160	155	160	160	160	145	135	145	110	90	80	95	80	80	90	85	130
Wyo:	Laramie	105	105	130	115	115	110	130	120	130	105	80	105	60	75	75	70	101
Network average		134	135	141	138	140	135	126	133	110	94	80	94	69	72	77	73	109
Maximum		265	260	270	265	265	275	270	260	260	255	245	255	225	210	190	210	231
Minimum		20	20	30	25	35	30	20	30	20	25	30	25	20	20	25	25	25

comparing December 1963 and December 1964 mean concentrations, table 4.

At no time during 1964 did levels of strontium-89, strontium-90, iodine-131, or cesium-137 concentrations in pasteurized milk reach levels such that remedial actions are suggested based upon health implications.

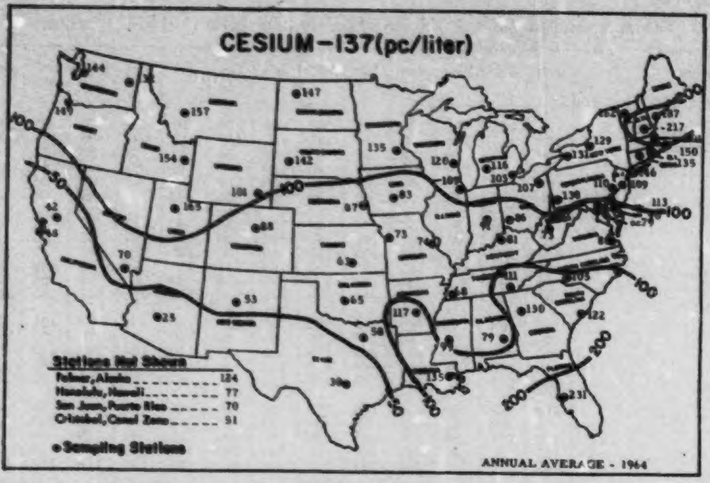
CESIUM-137(pc/liter)
Stations Not Shown
Palmer, Alaska 124
Honolulu, Hawaii 77
San Juan, Puerto Rico 70
Cristobal, Canal Zone 51
● Sampling Stations
ANNUAL AVERAGE - 1964

FIGURE 7. CESIUM-137 CONCENTRATIONS IN PASTEURIZED MILK

2. Colorado Milk Network, October–December 1964 and Summary for 1962–1964

Occupational and Radiological Health Division, Colorado State Department of Public Health

The Radiological Health Division of the Colorado State Department of Public Health initiated radiological analysis of milk in January 1962. Initially the Denver City and County Health Department collected a weekly composite milk sample from the major producers in the Denver area for the State, as it had for the Public Health Service since March 1960.

In August 1962, the State expanded its program to include the routine sampling of raw milk from the four major milk producing areas supplying the State: northeast, southeast, and west Colorado, and eastern Utah. The four

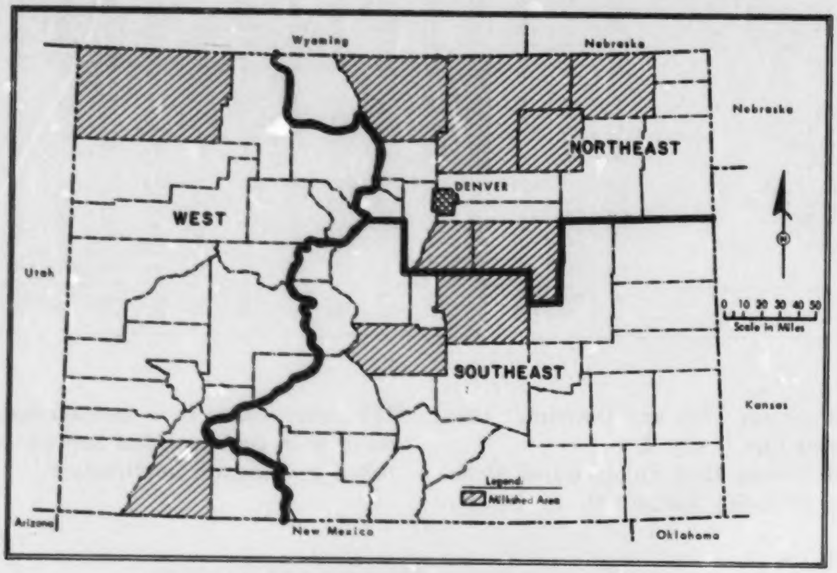
Wyoming
Nebraska
Nebraska
NORTHEAST
DENVER
WEST
Utah
SOUTHEAST
0 10 20 30 40 50
Scale in Miles
Kansas
Legend:
Milkshed Area
Arizona
New Mexico
Oklahoma

FIGURE 8. COLORADO MILK SAMPLING AREAS

major Colorado milk sampling areas are shown in figure 8. Sampling frequencies vary from one to seventeen times per month in each active sampling area. Sampling in western and southeastern Colorado was discontinued from September 1963 to June 1964.

Analytical Methods

The samples are analyzed for gamma emitting radionuclides at the State's low level counting facility. The analytical procedure utilizes an 8-foot cube steel shield having 5-inch steel walls, lined with ⅛-inch of lead. A 2-quart milk sample is gamma scanned in a stainless steel container, utilizing a 3 x 5-inch thallium-activated sodium iodide crystal detector and a 512-channel pulse height analyzer. The system is calibrated for the calculation of iodine-131, barium-140, cesium-137, and potassium-40 by a matrix method. The minimum detectable amount of the first three radionuclides is 20 pc/liter at the 95 percent confidence level (± 1.96 standard deviations).

Results and Discussion

Table 9 gives the potassium, iodine-131, and cesium-137 in milk samples collected from October 1964 through December 1964 and a summary of the results for 1962 to 1964. These data are presented graphically by area and month in figure 9.

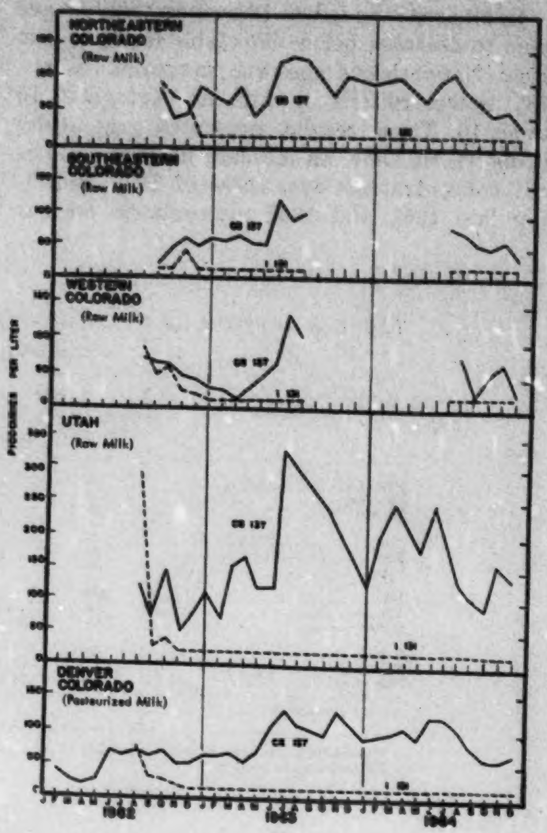

FIGURE 9. RADIONUCLIDE CONCENTRATIONS IN COLORADO MILK, 1962–1964

TABLE 9.—RADIONUCLIDES IN COLORADO MILK, OCTOBER 1964—DECEMBER 1964, AND SUMMARY •

[Radionuclide concentrations in pc/liter]

Date	Raw milk												Pasteurized milk		
	Northeast			Southeast			West			Eastern Utah			Denver		
	K (g/l)	I^{131}	Cs^{137}	K (g/l)	I^{131}	Cs^{137}	K (g/l)	I^{131}	Cs^{137}	K (g/l)	I^{131}	Cs^{137}	K (g/l)	I^{131}	Cs^{137}
1962 Annual Average	1.57	<57	58	1.55	25	44	1.57	51	60	1.56	<118	92	1.59	<28	50
1963 Annual Average	1.48	<20	94	1.51	<20	75	1.45	<20	60	1.50	<20	162	1.49	<20	113
1964 Quarterly Averages:															
Jan—Mar	1.28	<20	100	NS	NS	NS	NS	NS	NS	1.33	<20	193	1.32	<20	97
Apr—June	1.33	<20	83	NS	NS	NS	NS	NS	NS	1.46	<20	206	1.46	<20	109
July—Sept	1.46	<20	92	1.43	<20	67	1.20	<20	49	1.34	<20	112	1.51	<20	100
October	1.49	<20	56	1.39	<20	51	1.38	<20	57	1.54	<20	94	1.51	<20	62
November	1.26	<20	67	1.08	<20	57	1.23	24	74	1.41	<20	163	1.26	<20	61
December	1.29	<20	37	1.39	<20	25	NS	NS	NS	1.40	<20	137	1.58	<20	65
Oct—Dec	1.41	<20	56	1.31	<20	46	1.28	<20	68	1.47	<20	124	1.47	<20	63
1964 Annual Average	1.38	<20	79	1.39	<20	60	1.25	<20	60	1.41	<20	145	1.45	<20	91

NS indicates no sample collected.

• *Correction for previous Colorado data:* In the October 1964 issue of RHD, the "K^{40}" column in table 4 should have been labeled "K".

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In all areas the iodine-131 concentrations are seen to decrease below detectable levels in late 1962. Network averages and ranges of cesium-137 concentrations in milk are presented in table 10. These results, presented graphically in figure 10, show an increase in 1963 cesium-137 concentrations over those of 1962, reflecting late 1961 and 1962 atmospheric nuclear testing. However, a decrease is seen in 1964 which can be expected to continue with the discontinuation of atmospheric nuclear testing.

Previous Coverage in Radiological Health Data:

Period	Issue
January 1962–June 1964	*October 1964*
July–September 1964	*February 1965*

TABLE 10.—CESIUM-137 IN COLORADO MILK-MONTHLY AVERAGES 1962–1964

[Concentrations in pc/liter]

Month	1962		1963		1964	
	Average	Range	Average	Range	Average	Range
January	22	ᵃ <20–28 (2)	61	36–100 (4)	98	94–133 (3)
February	30	40 (1)	60	30–73 (5)	115	97–211 (3)
March	27	27 (1)	74	<20–150 (5)	117	100–236 (3)
April	21	21 (1)	53	34–167 (5)	98	84–108 (3)
May	28	28 (1)	66	46–122 (5)	91	70–186 (3)
June	72	72 (1)	110	67–129 (5)	120	96–226 (3)
July	NS		152	90–326 (5)	115	75–123 (3)
August	96	70–117 (3)	115	100–130 (4)	94	68–121 (4)
September	65	22–84 (5)	NS		72	20–104 (4)
October	72	41–143 (5)	139	79–239 (3)	58	51–94 (5)
November	52	48–60 (5)	121	107–135 (2)	82	57–163 (5)
December	53	44–80 (5)	NS		62	25–137 (5)
Annual average	63	—	91	—	87	—

ᵃ Numbers in parentheses indicate number of samples.
NS indicates no sample.

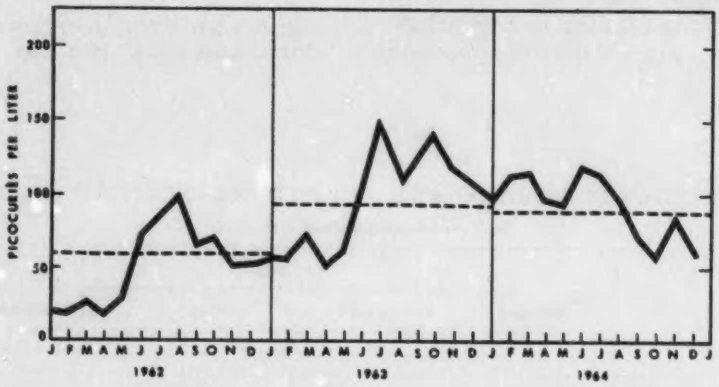

FIGURE 10. MONTHLY AVERAGE CESIUM-137 CONCENTRATIONS IN COLORADO MILK

3. New York Milk Network
July–September 1964

Division of Environmental Health Services, State of New York Department of Health

Pasteurized milk samples collected routinely from six cities—Albany, Buffalo, Massena, Newburgh, New York City, and Syracuse (figure 11)—are analyzed for their radionuclide content by the State of New York Department of Health. The samples are collected daily and composited weekly for the determination of strontium-89, strontium-90, iodine-131, and barium-lanthanum-140 at all stations except Massena, where samples are composited biweekly, and at New York City, where one daily milk sample representing the total milk supply for that day is obtained and analyzed once per week. Samples are obtained from processing plants except at Albany, where the daily sample is obtained from a marketing point. During periods when cows are not on stored feed, the sample from Albany is analyzed daily for iodine-131. In the event that any city reports iodine-131 concentrations exceeding 100 pc/liter, increased surveillance is undertaken.

Analytical Procedures

Gamma-emitting radionuclide concentrations in milk are determined by scintillation spectrometry and the application of a matrix method of analysis (4) to the resultant spectral data. This method is based upon the solution of simultaneous equations describing the individual spectral contributions of gamma emitting radionuclides to the total spectrum.

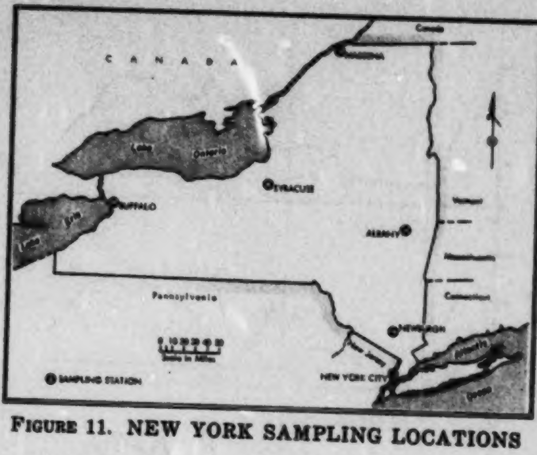

FIGURE 11. NEW YORK SAMPLING LOCATIONS

The analytical procedure for determining strontium-89 and strontium-90 concentrations employs an ion-exchange system. The collected cations (including radiostrontium), are eluted from the ion exchange resin with sodium chloride solution. The strontium isotopes are then gathered by means of sodium carbonate and isolated with ethylenediaminetetraacetic acid (EDTA). The radiostrontium is determined with a low background beta counter having an 0.8 mg/cm² window. The strontium-90 is determined differentially from the 40-hour ingrowth of its daughter product yttrium-90.

Results

The monthly average radionuclide concentrations of strontium-89, strontium-90, and cesium-137 are shown in table 11 for July 1964 to September 1964. The cesium-137 and iodine-131 concentrations since September 1961 are presented graphically in figure 12.

TABLE 11.—RADIONUCLIDE AVERAGE CONCENTRATIONS IN NEW YORK MILK [a]

[Concentrations in pc/liter]

Sampling location	Strontium-89			Strontium-90			Cesium-137		
	July	Aug	Sept	July	Aug	Sept	July	Aug	Sept
Albany	<3	<3	<3	18	14	13	78	70	54
Buffalo	<3	<3	<3	17	13	12	84	58	56
Massena	13	3	<3	16	19	15	131	110	89
Newburgh	<3	3	4	21	19	15	99	75	66
New York City	<3	<3	6	28	19	17	111	91	64
Syracuse	<3	<3	<3	14	13	13	66	61	52
Average	4	<3	<3	19	16	14	95	78	64

[a] Monthly I^{131} and Ba-La^{140} (in equilibrium) levels at each station less than the minimum detectable concentration of 20 pc/l. Ba-La^{140} refers to the combined concentration of these radionuclides at equilibrium.

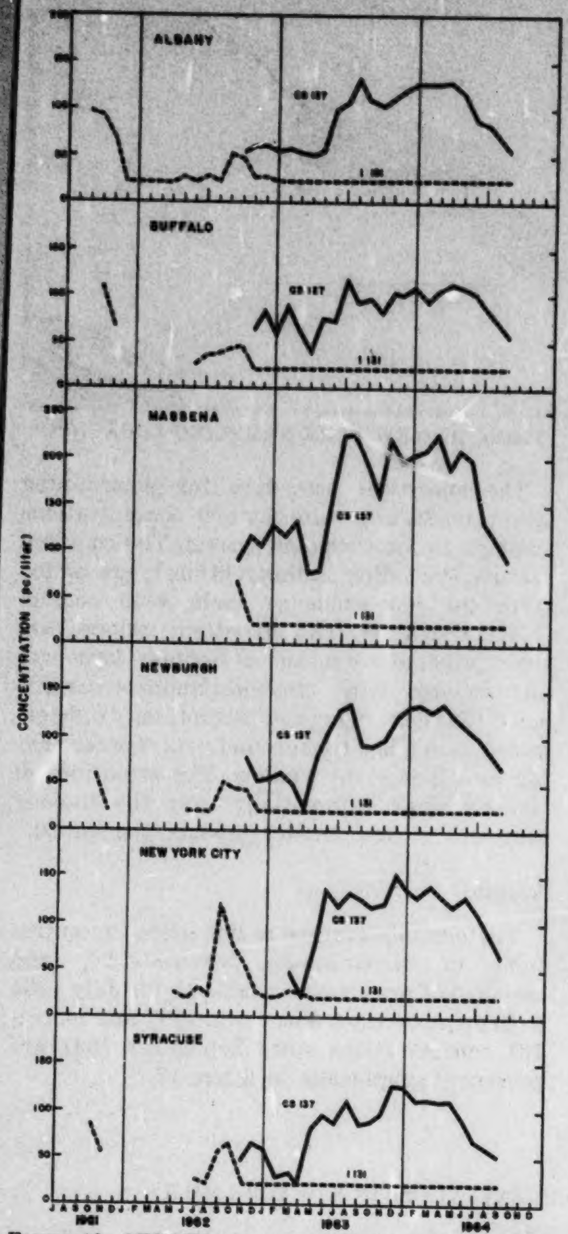

FIGURE 12. CESIUM-137 AND IODINE-131 IN NEW YORK MILK, JULY 1961–SEPTEMBER 1964

4. Canadian Milk Network[3]
December 1964

Radiation Protection Division, Department of National Health and Welfare, Ottawa, Canada

The Radiation Protection Division of the Department of National Health and Welfare began monitoring milk for strontium-90 in November 1955. At first, analyses were carried out on samples of powdered milk obtained from processing plants. However, since January 1963 liquid whole milk has been analyzed instead. With this change, more representative samples of milk consumed can be obtained, and milk sampling locations (see figure 13) can be chosen in the same areas as the air and precipitation stations. At present the analyses include determinations of iodine-131, strontium-89, cesium-137, and strontium-90 as well as stable potassium and calcium.

The milk samples are obtained through the cooperation of the Marketing Division of the Canadian Department of Agriculture. At each station samples are collected three times a week from selected dairies, combined into weekly composites, and forwarded to the radiochemical laboratory in Ottawa. The contribution of each dairy to the composite sample is directly proportional to its volume of sales. In most cases a complete sample represents over 80 percent of the milk processed and distributed in the area. Several of the weekly samples are randomly selected and analyzed for iodine-131. The results of the spot checks for iodine-131 will not be reported unless there is evidence that the levels are rising. A monthly composite of the samples is analyzed for strontium-90, cesium-137, stable potassium and calcium.

Analytical Methods

Radiochemical methods are used for the analysis of iodine-131 (*5*). For the analysis of radiostrontium, carrier strontium is added to a one-liter sample of milk. The milk is then placed in a tray lined with a polyethylene sheet and evaporated under infra-red lamps. The residue is ashed in a muffle furnace at 450 degrees C. and dissolved in dilute nitric acid. Strontium is separated by fuming nitric acid precipitation.

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[3] Data from *Radiation Protection Programs*, Vol. 3, No. 1: 48–49, Radiation Protection Division, Canadian Department of National Health and Welfare (Jan. 1965).

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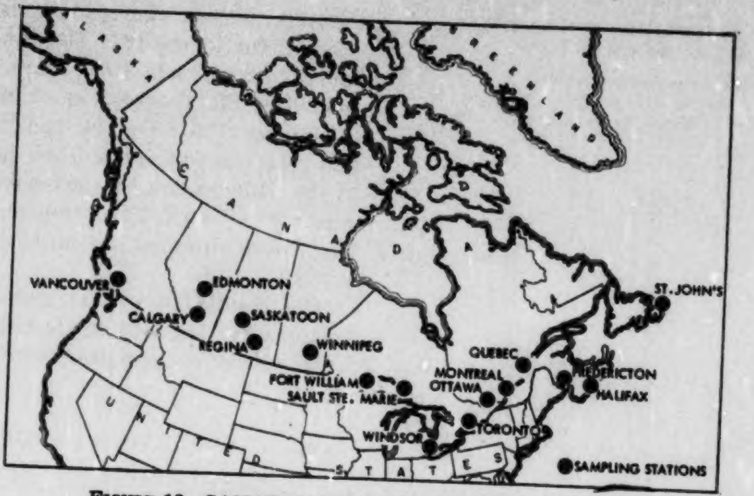

FIGURE 13. CANADIAN MILK SAMPLING STATIONS

The combined strontium-89 and strontium-90 are determined by counting in a low background beta counter. Strontium-90 is determined separately by extracting and counting its yttrium-90 daughter, while strontium-89 is estimated by difference from the total radiostrontium measurement. Appropriate corrections are made for self-absorption and counter efficiency at all stages. Calcium is determined by flame photometry.

Cesium-137 is determined by gamma spectroscopy using a scintillation crystal and a multichannel pulse height analyzer. A sample consisting of 4.5 liters of milk is placed in a sample tray constructed in the form of an inverted well to accommodate the 5 x 4-inch sodium iodide crystal detector. The sample is counted for 100 minutes and the gamma spectrum recorded. Estimates are made of the potassium-40 and cesium-137 content of the milk by comparison of the spectrum with the spectra of standard preparations of these two radionuclides. With this method the potassium-40 concentration is determined and the Compton contribution of this radionuclide to the cesium-137 photopeak is subtracted to obtain the cesium-137 concentration. The stable potassium content is estimated from the potassium-40 concentration.

Sources of Error

In the iodine and strontium determinations, tests indicate that the statistical error (95 percent confidence level) in the chemical operations involved is about plus-or-minus 10 percent. This value is independent of the concentration of the radioisotope in the milk because it depends only on the recovery of the carrier. In the determination of cesium-137 this factor is not involved.

The chemical procedures error must be combined with the counting error, which depends primarily on the concentration of the nuclide in the sample, the background radiation, and the length of time the sample and background are counted. This counting error has been evaluated mathematically for the particular counting arrangement used.

The overall errors, estimated on the basis indicated above, are given in table 12.

TABLE 12.—TOTAL ERROR FOR VARIOUS RADIONUCLIDE CONCENTRATIONS IN MILK [a]

Nuclide	Error for 10 pc/liter	Error for 50 pc/liter	Error for 100 pc/liter
Strontium-89	±50%	±20%	±10%
Strontium-90	±15%	±10%	±10%
Iodine-131	±25%	±20%	±15%
Cesium-137	±60%	±25%	±10%

[a] All errors are 2σ values, representing 95 percent confidence levels.

Results

Table 13 presents monthly averages of strontium-90, cesium-137, and stable calcium and potassium in Canadian whole milk. Spot checks for iodine-131 and strontium-89 indicate that all samples had < 5 pc/liter.

TABLE 13.—RADIONUCLIDES IN CANADIAN WHOLE MILK, DECEMBER 1964

[Radionuclide concentrations in pc/liter]

Station	Calcium (g/liter)	Potassium (g/liter)	Strontium-90	Cesium-137
Calgary	1.17	1.6	23.3	111
Edmonton	1.15	1.6	25.8	126
Ft. William	1.11	1.6	38.8	197
Fredericton	3	1.7	37.5	204
Halifax	7	6	36.1	242
Montreal	3	7	27.3	155
Ottawa	5	7	21.8	123
Quebec	1	6	41.8	257
Regina	3	6	31.1	125
St. John's, Nfld	3	5	34.4	209
Saskatoon	5	6	30.6	110
Sault Ste. Marie	3	7	35.9	193
Toronto	3	7	14.3	87
Vancouver	7	6	40.3	282
Windsor	3	6	13.6	78
Winnipeg	3	6	30.7	159
Average	1.14	1.6	30.2	166

Network average concentrations of stable calcium and potassium, strontium-90, and cesium-137 for 1963 and 1964 are given in table 14.

Cesium-137 levels in Canadian milk increased in the fall of 1963, but decreased in the spring of 1964 (figure 14). Strontium-89 and iodine-131 were below detectable levels during 1964, except for the period from October 19 to November 13, 1964. Iodine-131 results are shown in table 15.

After the Chinese nuclear test explosion on October 16, 1964, arrangements were made to initiate an extensive measurement program of iodine-131 in fluid milk, should this become necessary. In the meantime, as a precautionary measure, weekly composite milk samples were checked for iodine-131. The concentrations observed were much lower than those reported following the resumption of nuclear tests in September 1961. By the end of October they had returned to the low level that existed prior to the Chinese test and extensive measurement was not initiated. The strontium-89 concentrations were observed to remain below detectable levels.

The results show that radionuclide concentrations in Canadian whole milk remained well below the levels permissible on health grounds.

TABLE 15.—IODINE-131 IN CANADIAN WHOLE MILK

[Concentrations in pc/liter]

Station	Time intervals					Average
	10/19/64–10/23/64	10/26/64–10/30/64	11/2/64–11/6/64	11/9/64–11/13/64	11/16/64–11/20/64	
Calgary	0	47	5	8	N.S.	16
Edmonton	8	34	17	7	N.S.	17
Ft. William	0	38	11	5	N.S.	19
Fredericton	2	[a] N.S.	4	0	N.S.	2
Halifax	2	5	9	3	N.S.	5
Montreal	0	28	9	5	N.S.	11
Ottawa	4	[b] 7(2)	8(3)	3(3)	0(2)	5
Quebec	6	11	23	5	N.S.	11
Regina	0	8	6	1	N.S.	4
St. John's	3	16	6	6	N.S.	8
Saskatoon	0	16	11	11	N.S.	10
Sault Ste. Marie	2	27	8	2	N.S.	10
Toronto	2	27	33	12	N.S.	19
Vancouver	2	4	4	2	N.S.	3
Windsor	0	47	32	11	N.S.	23
Winnipeg	0	79	23	9	N.S.	28
Average	2	26	13	5	0	11

[a] N.S. indicates no sample collected.
[b] Parentheses indicate number of samples.

TABLE 14.—AVERAGE MONTHLY CONCENTRATIONS OF RADIONUCLIDES IN CANADIAN MILK, 1963–1964

Month	1963				1964			
	Ca (g/liter)	K (g/liter)	Sr-90 (pc/liter)	Cs-137 (pc/liter)	Ca (g/liter)	K (g/liter)	Sr-90 (pc/liter)	Cs-137 (pc/liter)
January	1.10	[a] NA	19.2	3	1.37	1.6	43.1	254
February	1.25	NA	19.1	63	1.31	1.6	41.3	250
March	1.16	NA	18.7	53	1.36	1.6	40.6	251
April	1.23	NA	17.5	80	1.38	1.6	41.5	246
May	1.13	NA	24.5	112	1.40	1.6	46.4	245
June	1.31	NA	45.2	167	1.40	1.6	42.5	227
July	1.31	NA	46.4	239	1.11	1.6	37.9	200
August	1.36	NA	52.7	260	1.10	1.6	32.5	175
September	1.31	1.5	52.3	232	1.15	1.6	31.8	147
October	1.29	1.5	45.0	203	1.15	1.6	33.7	141
November	1.25	1.4	42.3	230	1.16	1.6	33.1	143
December	1.25	1.6	40.5	245				

[a] NA indicates no analysis.

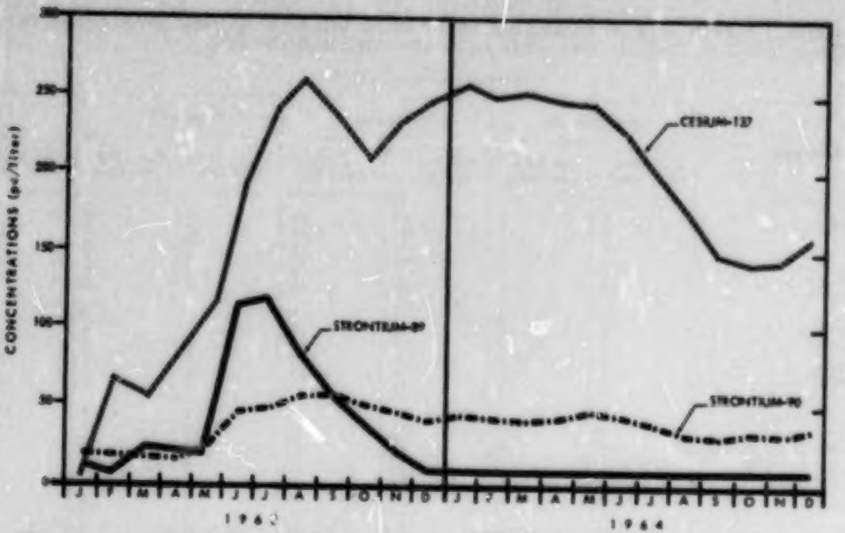

FIGURE 14. NETWORK AVERAGE STRONTUM-89, STRONTIUM-90 AND CESIUM-137 CONCENTRATIONS IN CANADIAN WHOLE MILK

REFERENCES

(*1*) PUBLIC HEALTH SERVICE. Summary of results from the raw milk sampling program, June 1957–April 1963. Rad Health Data 4: 511–23 (October 1963).

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(*3*) Geographical Variation in Radionuclide Content of Milk (1962). Rad Health Data 5: 185–187 (April 1963).

(*4*) KAHN, B. et al. Rapid methods for estimating fission product concentrations in milk. Public Health Service Publication No. 999–R–2 (March 1963). Single copies available on request from Public Inquiries Branch, PHS, U. S. Department of Health, Education, and Welfare, Washington, D.C. 20201.

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APPLICATION OF RADIONUCLIDE CONCENTRATIONS IN MILK TO DOSE ASSESSMENT, JANUARY-DECEMBER 1964

Division of Radiological Health, Public Health Service

The concentrations of specific radionuclides in milk analyzed as part of the Pasteurized Milk Network (PMN) are reported on a monthly basis in *RHD*. In terms of radiological health surveillance activities, an important aspect of these data is the estimation of resultant radiation dose to population groups.

Approximate relationships between certain radionuclide intakes and dose have been applied to the formulation of daily intake guides (*1*) and permissible concentrations in selected environmental media (*2*). Although these guides are not themselves directly applicable to worldwide fallout, a comparison with environmental contamination levels does yield a measure of population dosage. In general, intake-dose and dose-biological effect relationships used in formulating the guides cited are based on continuous intake over an entire lifetime. However, for general surveillance purposes, yearly average intakes, used with discretion, may be compared directly with the levels adopted as lifetime intake guides. Thus, the radionuclide concentrations in milk, averaged over a year's time, together with milk consumption data, might be used in conjunction with the references cited above to approximate the radiation dose to a specific population group from a specific radionuclide. Table 1 presents annual averages of radionuclide concentrations in milk sampled by the PMN. Limited data are available for estimating the average daily milk consumption (on a volume basis) for specific age groups in the U.S. population (*3*,*4*).

TABLE 1.—AVERAGE RADIONUCLIDE CONCENTRATIONS IN MILK, FOR THE TWELVE MONTH PERIODS,[a] DECEMBER 1963–NOVEMBER 1964 AND JANUARY–DECEMBER 1964.

[Concentrations in pc/liter]

Sampling locations		Strontium-89		Strontium-90		Iodine-131		Cesium-137	
		Dec 1963–Nov 1964	Jan 1964–Dec 1964	Dec 1963–Nov 1964	Jan 1964–Dec 1964	Dec 1963–Nov 1964	Jan 1964–Dec 1964	Dec 1963–Nov 1964	Jan 1964–Dec 1964
Ala:	Montgomery	3	3	21	22	0	0	82	79
Alaska:	Palmer	6	3	21	21	0	0	130	124
Ariz:	Phoenix	3	3	4	4	0	0	25	25
Ark:	Little Rock	3	3	44	46	0	1	122	117
Calif:	Sacramento	3	3	8	8	0	0	45	42
	San Francisco	3	3	10	10	0	0	51	48
C. Z.:	Cristobal	3	3	5	5	0	0	51	51
Colo:	Denver	4	3	19	19	0	0	89	88
Conn:	Hartford	3	3	21	20	0	0	142	135
Del:	Wilmington	3	3	22	22	1	1	110	113
D. C.:	Washington	3	2	19	19	0	0	82	79
Fla:	Tampa	3	3	18	18	0	0	223	221
Ga:	Atlanta	3	3	31	31	0	0	134	130
Hawaii:	Honolulu	3	3	12	12	0	0	77	77
Idaho:	Idaho Falls	10	10	27	26	0	0	162	164
Ill:	Chicago	3	3	19	19	0	0	112	109
Ind:	Indianapolis	3	3	21	20	1	1	96	91
Iowa:	Des Moines	5	4	25	25	0	0	87	83
Kans:	Wichita	4	4	21	21	0	0	63	63
Ky:	Louisville	3	3	20	20	0	0	88	81
La:	New Orleans	4	4	21	20	0	0	139	135
Maine:	Portland	3	3	20	20	1	1	194	187
Md:	Baltimore	3	3	22	22	0	0	96	90
Mass:	Boston	3	3	33	31	0	0	213	203
Mich:	Detroit	3	3	18	18	2	2	109	105
	Grand Rapids	3	3	21	21	1	1	120	118
Minn:	Minneapolis	7	7	33	31	0	0	141	135
Miss:	Jackson	4	4	41	40	0	0	104	99
Mo:	Kansas City	6	5	27	27	0	0	77	73
	St. Louis	5	4	23	23	0	0	78	74
Mont:	Helena	5	5	25	25	1	1	166	157
Nebr:	Omaha	5	4	26	25	0	0	90	87
Nev:	Las Vegas	3	3	10	10	1	1	73	70
N. H.:	Manchester	3	3	30	30	1	1	226	217
N. J.:	Trenton	3	3	19	19	1	1	112	109
N. Mex:	Albuquerque	3	3	11	11	1	1	53	53
N. Y.:	Buffalo	3	3	20	20	0	0	136	131
	New York	3	3	25	25	1	1	153	146
	Syracuse[b]	3	3	20	19	0	0	134	129
N. C.:	Charlotte	3	3	25	26	0	0	109	105
N. Dak:	Minot	12	11	56	54	0	0	149	147
Ohio:	Cincinnati	3	3	22	22	0	0	90	88
	Cleveland	3	3	21	21	0	0	110	107
Okla:	Oklahoma City	3	3	22	22	0	0	68	65
Ore:	Portland	6	5	30	30	0	0	154	149
Pa:	Philadelphia	3	3	20	20	0	0	115	110
	Pittsburgh	3	3	29	29	0	0	143	138
P. R.:	San Juan	3	3	12	12	0	0	73	70
R. I.:	Providence	3	3	21	23	0	0	157	150
S. C.:	Charleston	3	3	22	22	0	0	124	122
S. Dak:	Rapid City	6	5	41	39	0	0	146	143
Tenn:	Chattanooga	4	4	41	40	0	0	116	111
	Memphis	3	3	22	22	0	0	70	66
Tex:	Austin	3	3	9	9	0	0	39	38
	Dallas	3	3	19	19	0	0	62	58
Utah:	Salt Lake City	6	6	25	25	0	0	172	165
Vt:	Burlington	3	3	26	25	2	2	170	162
Va:	Norfolk	3	3	18	18	0	0	91	88
Wash:	Seattle	7	6	25	26	0	0	148	144
	Spokane	6	6	28	28	0	0	135	132
W. Va:	Charleston	3	3	20	25	0	0	78	73
Wis:	Milwaukee	3	3	18	17	1	1	125	120
Wyo:	Laramie	8	7	20	20	0	0	104	101
Network average		4	4	24.1	23.7	0	0	113	109

[a] Annual averages were computed on basis of 52 weekly averages. Annual averages for barium-140 were all <10.

[b] Annual averages were computed on basis of 48 weekly averages for this station only as no samples were collected during July 1964.

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Total dietary intake is of prime interest, and since the intake via milk consumption constitutes only a portion of the total radionuclide intake, the relationship of milk intake to total dietary intake is of importance in evaluating milk surveillance data. The Federal Radiation Council (*5*) notes: "A number of studies have shown that conservative estimates of the strontium-90 to calcium ratio in the total diet may be made by multiplying the ratio of strontium-90 to calcium in milk in a particular locality by 1.5."[1] Thus, a rough index of the total dietary intake of strontium-90 on an annual basis may be made from PMN annual averages by using this factor and the assumption of approximately 1.2 g of calcium per liter in PMN samples and 1.0 g daily intake of calcium.

In the case of iodine-131, milk can be considered the major source because of the rapid distribution and consumption of fresh milk. With most other foods, normal processing and distribution allows time for this short-lived nuclide to decay to insignificant levels.

The situation with respect to strontium-89 is more complicated. Its half-life of some 50 days makes it difficult to estimate the relative contribution made by sources other than milk to the total dietary intake.

The relative contribution of milk to the total dietary intake of cesium-137 is not well defined and depends principally on the amount of freshly deposited cesium-137 on products used for human and animal consumption, and the progress of cesium-137 through the food chain.

The data in table 1 are calculated as follows: results from all samples collected in each week (Sunday through Saturday) are averaged, and the averages for all weeks terminating in each of twelve consecutive months are averaged to obtain the annual average.[2] To obtain the annual average daily intake (pc/day) of radionuclides from milk, the annual average concentration values (pc/liter) in table 1 must be multiplied by the annual average daily consumption (liters/day) of milk.

Monthly variations of radionuclide concentrations in milk are influenced by a number of combined causes such as meteorologic conditions and dairying practices, apart from considerations of original sources of radionuclides. The moving yearly average (table 1) obtained by updating the previous twelve-month average by one month, shows variations averaged over the year and tends to minimize purely seasonal variations.

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[1] This ratio may vary from 1 to 2, depending on changes in rate of fallout deposition and relative consumption of non-milk products, whose contamination reflects temporal and local distribution patterns (6).

[2] Beginning with the October 1963 data, iodine-131 values of <10 pc/liter are considered to be zero for averaging purposes; previously, 5 pc/liter was used for calculating the averages.

COMPARISON OF RADIONUCLIDE CONCENTRATIONS IN MILK FROM DISTRIBUTORS SERVING THE CITY OF BOSTON

E. J. Baratta,[1] *M. A. Wall,*[2] and *H. Mazer*[3]

Introduction

The Public Health Service Pasteurized Milk Network, (PMN) established in 1960, monitors the radionuclide content of fluid milk consumed in 63 cities in the United States. Sampling procedures were designed to include a sufficient number of distributors to assure that the samples collected were representative of the milk being consumed. At most stations the actual sample represents from 80 to 100 percent of the milk processed in the area (*1*) and, ideally, the sample is composited by drawing from each of the distributors a volume proportional to its share of the market.

The purpose of this study was to compare the radionuclide content of milk from each of the six major distributors, who supply a total of 99 percent of the fluid milk consumed in the city of Boston, with that of the local sample collected for the Pasteurized Milk Network. Such a comparison would indicate whether the reported PMN average radionuclide content was representative of the milk consumed by an individual customer of any one of the six major distributors.

Three of the six companies supply about 82 percent of the milk consumed in Boston. All six distributors are served by dairy farms in Maine, New Hampshire, Vermont, Massachusetts, and New York. As would be expected, there is considerable overlap of their respective milksheds.

The best sampling procedure would be one that obtained an "ideal" sample, composited from samples from the six distributors, weighted according to their respective outputs. When this study was initiated, the Network station sample consisted of equal parts from the three dealers selling 82 percent of the milk, on the assumption that each sold about 27 percent of the total volume. Since this was not the actual situation, an auxiliary purpose of this study was to investigate the validity of the sampling procedure, in order to determine whether the radionuclide content in the Network sample approximated that of an ideal sample.

Data Collection and Presentation

The study was conducted from January to December 1963 and weekly samples were collected from each of the six companies. To reduce the analytical work-load, four consecutive weekly samples from each distributor were composited and analyzed for strontium-90, cesium-137, and strontium-89, the three fallout nuclides present in detectable amounts at the time of the study.

The results of the strontium-90 determinations in all samples are shown in table 1. By using the data for the *three* largest companies, a calculated *weighted* average (proportional to the milk volume as distributed) and an *unweighted* calculated average were obtained. Calculated *weighted* averages for all *six* distributors also appear in the table. Similar data for cesium-137 and strontium-89 are shown in tables 2 and 3, respectively.

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TABLE 1.—STRONTIUM-90 IN BOSTON MILK, BY DISTRIBUTOR—1963

[Concentrations in pc/liter]

Sampling period	Distributor						Network station sample average	Calculated average of three largest distributors		Calculated average of six major distributors (Weighted)
	A	B	C	D	E	F		Unweighted	Weighted	
1/2–1/25	13.6	15.9	25.7	13.5	21.6	23.7	18.2	18.4	17.7	18.1
1/29–2/19	15.6	18.4	19.9	21.4	10.8	12.3	15.1	18.0	17.5	17.0
2/26–3/19	20.7	22.2	17.9	13.9	14.9	19.5	23.8	20.3	20.2	19.4
3/26–4/16	11.3	15.1	10.4	24.2	14.6	14.9	22.1	12.3	11.9	12.9
4/23–5/14	17.4	19.6	18.4	15.2	18.6	23.0	17.1	18.5	18.2	18.3
5/21–6/11	41.0	43.6	51.6	35.3	41.6	49.3	37.8	45.5	44.8	44.3
6/18–7/9	35.6	45.2	54.7	44.0	39.3	35.7	50.7	45.2	43.4	42.8
7/16–8/6	46.6	50.3	45.7	34.5	40.2	46.3	52.0	47.5	47.1	45.9
8/13–9/3	41.5	50.7	46.5	39.5	39.0	49.0	43.6	46.2	45.0	44.6
9/10–10/1	35.1	45.0	38.2	35.0	31.0	43.2	38.5	39.4	38.2	37.9
10/8–10/29	35.4	41.6	36.5	45.2	34.6	58.7	35.8	37.8	37.1	38.7
11/5–11/26	31.8	38.9	35.8	38.2	29.2	41.6	37.3	35.5	34.6	34.9
12/3–12/23	30.6	42.0	39.0	42.0	30.0	48.5	34.8	37.2	33.9	36.5
1963 Avg	28.9	34.5	33.9	30.9	28.1	35.8	32.8	32.4	31.6	31.6

TABLE 2.—CESIUM-137 IN BOSTON MILK, BY DISTRIBUTOR—1963

[Concentrations in pc/liter]

Sampling period	Distributor						Network station sample average	Calculated average of three largest distributors		Calculated average of six major distributors (Weighted)
	A	B	C	D	E	F		Unweighted	Weighted	
1/2–1/25		DATA NOT AVAILABLE					100.7			
1/29–2/19	83.2	82.1	85.0	107.6	84.1	125.9	88.8	83.4	83.5	87.5
2/26–3/19	91.8	96.3	102.4	64.0	74.2	115.5	97.4	96.8	96.0	99.1
3/26–4/16	101.0	87.5	72.5	67.0	74.7	115.7	89.2	87.0	89.5	88.7
4/23–5/14	92.6	98.7	114.8	81.7	105.6	88.4	99.4	102.0	100.6	99.1
5/21–6/11	150.8	205.7	179.1	151.8	189.6	194.8	197.8	178.5	171.4	172.8
6/18–7/9	293.5	294.8	342.2	231.8	289.0	233.6	298.8	310.1	308.4	298.3
7/16–8/6	368.5	370.9	406.8	244.3	315.9	355.2	361.4	382.1	380.5	367.1
8/13–9/3	330.8	449.3	358.3	263.0	315.1	392.9	391.9	379.5	365.1	357.7
9/10–10/1	238.7	312.8	256.5	223.7	226.3	339.6	269.8	269.3	260.3	260.9
10/8–10/29	229.6	277.8	219.9	239.6	317.3	216.2	236.1	242.4	237.3	240.1
11/5–11/26	236.7	263.5	250.7	216.2	233.0	268.8	258.9	250.3	246.8	245.5
12/3–12/23	220.6	305.4	277.6	259.2	246.2	353.9	263.2	267.9	256.4	262.0
1963 Avg	203.1	237.1	222.1	179.2	205.9	233.4	211.8	220.8	216.3	214.5

TABLE 3.—STRONTIUM-89 IN BOSTON MILK, BY DISTRIBUTOR—1963

[Concentrations in pc/liter]

Sampling period	Distributor						Network station sample average	Calculated average of three largest distributors		Calculated average of six major distributors (Weighted)
	A	B	C	D	E	F		Unweighted	Weighted	
1/2–1/25	9.6	4.3	15.2	5.4	4.7	4.2	4.8	9.7	10.1	9.2
1/29–2/19	2.5	0.7	0.0	0.0	1.6	7.1	4.6	1.1	1.4	1.6
2/26–3/19	0.0	0.3	0.1	2.3	4.5	5.5	2.1	0.1	0.1	0.8
3/26–4/16	4.4	1.0	6.8	0.0	6.5	6.0	0.6	4.1	4.4	4.4
4/23–5/14	6.9	34.4	9.0	16.2	12.2	2.6	11.4	16.8	13.4	13.0
5/21–6/11	52.3	69.5	47.2	45.1	41.9	32.6	71.9	56.3	54.6	51.9
6/18–7/9	68.1	77.7	101.3	70.8	79.5	62.1	76.9	82.4	80.2	78.6
7/16–8/6	80.1	81.8	91.9	68.3	69.4	80.3	82.8	84.6	84.0	82.0
8/13–9/3	75.8	65.5	63.0	63.6	49.8	59.8	75.3	68.1	69.7	70.5
9/10–10/1	31.3	35.0	31.0	32.9	26.1	49.8	39.4	32.4	32.0	32.9
10/8–10/29	44.7	13.2	14.2	11.4	34.6	58.7	23.2	24.0	28.6	29.6
11/5–11/26	9.8	7.7	13.2	15.2	10.5	3.0	10.7	10.2	10.4	10.2
12/3–12/23	6.2	2.2	3.0	0.0	6.6	5.2	4.7	3.8	4.4	4.3
1963 Avg	30.1	30.3	30.5	25.5	26.8	29.0	31.4	30.3	30.3	29.7

The individual analytical results for strontium-90 in fluid milk from each of the six distributors are plotted in figure 1. Similar cesium-137 and strontium-89 data are shown in figures 3 and 5. Comparisons of the strontium-90 content of the Network sample with the calculated averages for the three major companies, both weighted and unweighted, and with the calculated weighted average for all six companies are presented in figure 2. Similar comparisons for cesium-137 and strontium-89 are shown in figures 4 and 6.

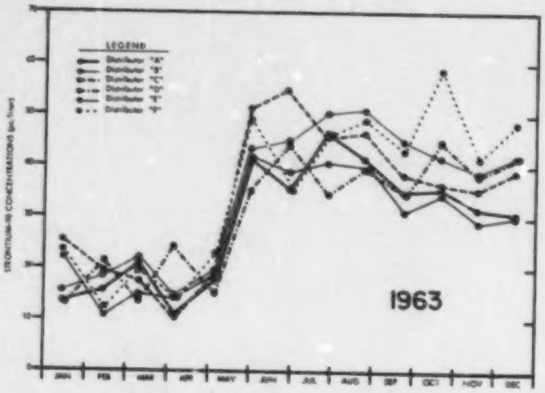

FIGURE 1. CONCENTRATIONS OF STRONTIUM-90 IN MILK FROM INDIVIDUAL DISTRIBUTORS

Discussion of Results

On the basis of the data presented, it is apparent (figures 1, 3, and 5) that the general month-by-month trend of radionuclide levels for milk from all six distributors was similar. For all companies there was a distinct rise in the concentrations of strontium-90, cesium-137, and strontium-89 about the first of May. A decline in strontium-89 levels began in late July or early August, while the cesium-137 decline began about one month later. The strontium-90 concentrations observed in the summer remained at roughly the same levels throughout the rest of the year. A rise in the strontium-89 and strontium-90 concentrations during the month of October was observed in milk from several of the distributors. Although the reason for this is not clear, it may be that the cows were able to graze on open pasture during this time due to mild weather.

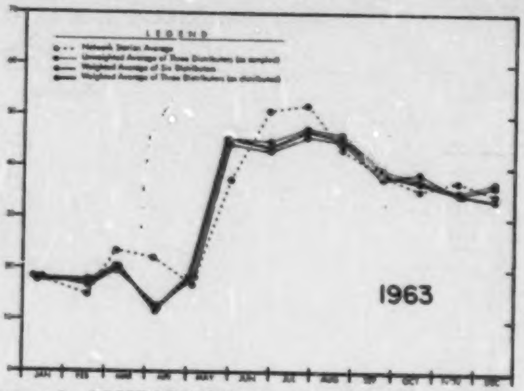

FIGURE 2. COMPARISON OF STRONTIUM-90 CONCENTRATIONS IN MILK FROM INDIVIDUAL DISTRIBUTORS WITH THOSE OF THE NETWORK STATION SAMPLE

The most valid comparison of the data is on the basis of yearly averages. This minimizes seasonal variation and reduces the effect of analytical errors. This is also in accordance with the recommendations of the Federal Radiation Council (2). The highest yearly average for the strontium-90 content in milk from any single dealer (tables 1, 2, and 3) was 35.8 pc/l (Distributor F), only 9 percent above the average for the Network station sample. The lowest yearly average (Distributor E) was only 15 percent below the average for the Network station sample. For cesium-137 the extremes were 11 percent above (Distributor B) and 15 percent below (Distributor D) the Network station sample. The strontium-89 extremes were 18 percent above and 3 percent below for Distributors D and C, respectively.

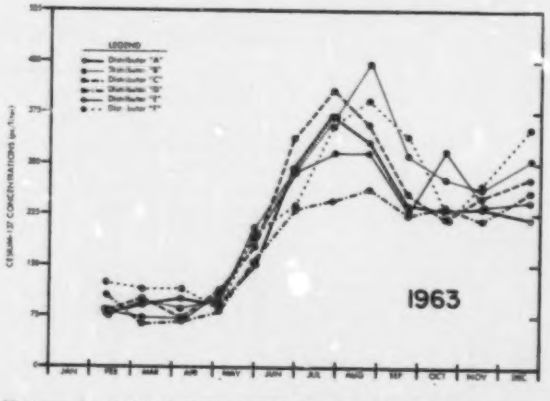

FIGURE 3. CONCENTRATIONS OF CESIUM-137 IN MILK FROM INDIVIDUAL DISTRIBUTORS

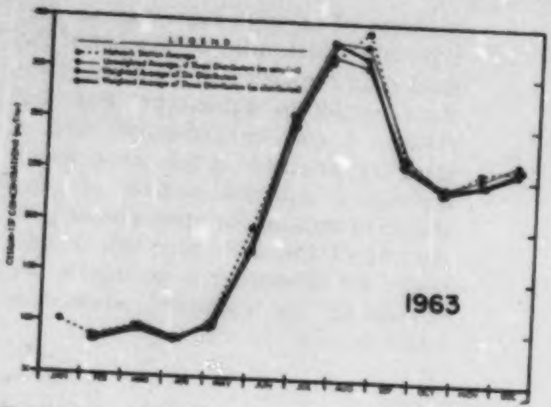

FIGURE 4. COMPARISON OF CESIUM-137 CONCENTRATIONS IN MILK FROM INDIVIDUAL DISTRIBUTORS WITH THOSE OF THE NETWORK STATION SAMPLE

The data demonstrate that the sampling technique used during the period of the study was not a source of appreciable error. Figures 2, 4, and 6 show that the calculated *monthly* averages for the three milk companies, both weighted and unweighted, were remarkably close to the values for the Network station sample. More important, these data closely corresponded to the calculated weighted averages for the milk from all six companies. On the basis of these data, it is apparent that the Network station sample, consisting of equal portions from each of the three major distributors, was adequate during the period of the study.

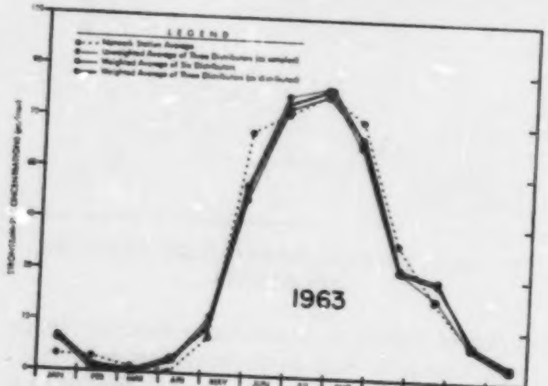

FIGURE 6. COMPARISON OF STRONTIUM-89 CONCENTRATIONS IN MILK FROM INDIVIDUAL DISTRIBUTORS WITH THOSE OF THE NETWORK STATION SAMPLE

There was remarkably close agreement for the three radionuclides between the yearly averages of the Network station sample and all of the corresponding calculated *yearly* averages, including the weighted and unweighted averages for the three largest distributors (A, B, and C) and the weighted average for the six distributors (A through F). For strontium-90 the calculated yearly average (unweighted) for the three largest companies was the same as the yearly average for the Network station sample (table 1). The comparable value for cesium-137 was 5 percent, and the calculated yearly average weighted for the six companies was only 3 percent, above the yearly average of the Network station sample (table 2). The strontium-89 calculated yearly averages were within 4 percent of the Network yearly average (table 3).

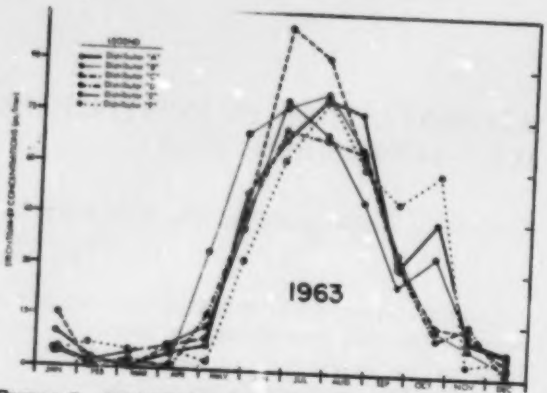

FIGURE 5. CONCENTRATIONS OF STRONTIUM-89 IN MILK FROM INDIVIDUAL DISTRIBUTORS

Conclusions

On the basis of these data it can be stated that, during the period of the study, in the city of Boston:

1. There was reasonably close agreement between the yearly average levels of strontium-90, cesium-137, and strontium-89 in the Network station sample and in the milk from each of the six major distributors serving the area. For this reason, it can be concluded that the Network station sample offered a good estimate of the radionuclide content of the fluid milk supplied by the individual companies commercially serving the city.

2. There was very close agreement between the yearly average levels for strontium-90, cesium-137, and strontium-89 in the Network station sample and the calculated averages based on the data from the individual analyses of the samples from the three major distributors, weighted according to the volume of milk distributed. Therefore, it can be concluded that the compositing procedure employed by the Pasteurized Milk Network, though not ideal, was adequate under the circumstances.

3. The yearly average levels of strontium-90, cesium-137, and strontium-89 in the Network station sample and in the weighted yearly averages, calculated from the data from the individual analyses of samples from the six distributors contributing 99 percent of the fluid milk consumed in the area, were substantially in agreement. For this reason it can be concluded that a sampling program in this area, which includes a sufficient number of companies to account for approximately 80 percent of the milk supplied, is adequate for preparing a composite for estimating the average radionuclide levels in milk.

REFERENCES

(*1*) DIVISION OF RADIOLOGICAL HEALTH. Pasteurized Milk Network. Rad Health Data, 5: 257 (June 1964).

(*2*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

RADIONUCLIDES IN INSTITUTIONAL DIET SAMPLES, JULY-SEPTEMBER 1964

Division of Radiological Health, Public Health Service

The determination of radionuclide concentrations in the diet constitutes an important element of an integrated program of environmental radiation surveillance and assessment. In recognition of the potential significance of the diet in contributing to total environmental radiation exposures, the Public Health Service initiated its Institutional Diet Sampling Program in 1961. This program is administered by the Division of Radiological Health with the assistance of the Division of Environmental Engineering and Food Protection (*1*).

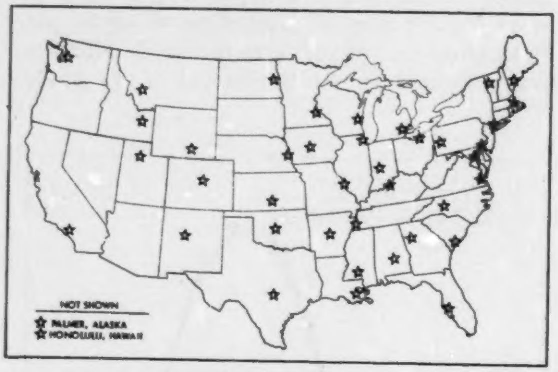

FIGURE 1. INSTITUTIONAL DIET SAMPLING LOCATIONS

The program is designed to estimate the dietary intake of radionuclides in a selected population group of children ranging up to 19 years of age. Initially, the program consisted of sampling diets in eight institutions, but it has since been expanded to 41 boarding schools or institutions, geographically distributed as shown in figure 1. Institutions selected range from fiancially well-to-do boarding schools to orphanages with severe economic limitations. Each institution (with the exception of Los

Angeles, California; Fargo, North Dakota; Columbia, Mississippi; and Carson City, Nevada) is located in a community from which the PHS Pasteurized Milk Network collects samples. The analytical data from this program supplement the findings for the Institutional Diet Sampling Program.

Sampling Procedure

The sampling procedure is essentially the same at each institution. Each sample represents the edible portion of the diet for a full 7-day week (21 meals plus soft drinks, candy bars, or other in-between snacks) obtained by duplicating the meals of a different individual each day. Each institution supplies one complete 7-day, 21-meal diet sample each month. Each day's sample is kept frozen during the collection period. After collection the total sample is packed in dry ice for shipment by air express to the Southwestern Radiological Health Laboratory, Las Vegas, Nevada; the Southeastern Radiological Health Laboratory, Montgomery, Alabama; or the Northeastern Radiological Health Laboratory, Winchester, Massachusetts.

The sample for each day is packaged in three parts: (1) solid food and semisolid foods minus those portions that would not ordinarily be eaten; (2) liquid milk; (3) other beverages such as soft drinks, coffee, and tea. Drinking water is not included in these samples or recorded in this report. A record of the contents of each meal and the approximate amount of each item is made at the institution and sent with the sample.

Analytical Procedures

Because calcium may have an effect on the uptake of important bone-seeking radionuclides such as strontium-89 and strontium-90 (*2*), it is included in the analytical program. Total weight is accurately determined in the laboratory. Stable calcium and stable potassium determinations are obtained by conventional gravimetric or spectrophotometric methods. Samples usually range from 6 to 16 liters in volume and weigh from 8 to 20 kilograms.

The radioanalysis program is designed around three basic procedures: (1) gamma spectroscopy; (2) chemical separation of strontium-89 and strontium-90 with subsequent counting; and (3) radium-226 analysis. In the absence of interferences other than that from naturally-occurring radioactive potassium (K^{40}), minimum detectable concentrations for the gamma scan for iodine-131, cesium-137, and barium-140 are 10 pc/kg. Approximate minimum detectable concentrations for strontium-89, strontium-90, and radium-226 are: 5, 1, and 0.1 pc/kg, respectively.

Data

Table 1 gives the results of the laboratory analyses of the food samples. In this table are presented concentrations of various radionuclides and stable elements expressed as picocuries per kilogram of diet or grams per kilogram of diet, respectively.

Table 2 presents the dietary intake data expressed on a per-day basis from July through September 1964 for the 41 institutions from which samples were received. The intake values in this table were obtained by multiplying the food consumption rate in kg/day times the concentration values in grams or picocuries per kilogram of diet given in table 1. Also contained in the table is the range of ages of the children from which samples were obtained each month. The reported radionuclide concentrations of these samples are extrapolated to the midpoint of the sample collection period.

Certain of the radioanalyses are reported by the laboratories as being "less-than" (<) a specified value. For data computations, the method employed is to use a zero for <10 pc/kg values for iodine-131 and barium-140. A 2.5 pc/kg value was substituted for a <5 pc/kg of strontium-89.

Recent coverage in *Radiological Health Data:*

Period	*Issue*
July–September 1963	*March 1964*
October–December 1963	*July 1964*
January–March 1964	*October 1964*
April–June 1964	*January 1965*

TABLE 1.—INSTITUTIONAL DAILY DIETARY INTAKE CONCENTRATIONS, THIRD QUARTER 1964

Location of institution	1964	Age (years)	Total weight (kg/day)	Calcium (g/kg)	Potassium (g/kg)	Radionuclide concentrations (picocuries/kg)					
						Radium-226 [a]	Strontium-89	Strontium-90	Cesium-137	Barium-140	Iodine-131
Ala., Montgomery	July	11-16	1.88	0.5	0.9	NA	5	13	50	<10	<10
	Aug	15-17	2.20	0.5	1.2	NA	<5	12	40	<10	<10
	Sept	15-17	2.23	0.5	1.0	NA	<5	9	50	<10	<10
Alaska, Palmer	July	10-16	1.60	0.6	1.5	0.4	5	24	100	<10	<10
	Aug	10-11	1.66	0.6	1.0	2.0	5	15	80	<10	<10
	Sept	11	1.63	0.3	1.1	0.7	<5	16	100	<10	<10
Ark., Little Rock	July	7-12	1.69	0.4	1.2	NA	5	22	50	<10	<10
	Aug	8-12	1.68	0.5	1.1	NA	<5	21	60	<10	<10
	Sept	10-12	1.67	0.7	1.0	NA	<5	29	45	<10	<10
Calif., Los Angeles	July	NS	[a] NS	NS	NS	NS	NS	NS	NS	NS	NS
	Aug	—	NS	NS	NS	NS	NS	NS	NS	NS	NS
	Sept	—	NS	NS	NS	NS	NS	NS	NS	NS	NS
Colo., Denver	July	10-17	2.50	0.5	1.4	0.7	<5	16	90	<10	<10
	Aug	10-17	2.53	0.6	1.4	1.3	5	16	70	<10	<10
	Sept	10-17	2.21	0.5	1.5	1.1	<5	7	50	<10	<10
Conn., Hartford	July	1-18	1.88	0.6	1.4	0.6	<5	14	90	<10	<10
	Aug	1-15	1.76	0.6	1.7	0.6	<5	12	100	<10	<10
	Sept	14-19	2.04	0.6	1.4	0.5	<5	10	70	<10	<10
Del., Wilmington	July	11-13	1.87	0.7	1.3	0.2	<5	13	70	<10	<10
	Aug	10-12	1.23	[b] NA	1.4	0.6	<5	14	70	<10	<10
	Sept	11-12	1.92	1.0	1.7	0.9	<5	17	70	<10	<10
Fla., Tampa	July	7-17	1.73	0.6	1.0	NA	<5	12	115	<10	<10
	Aug	9-16	1.81	0.6	0.9	NA	<5	11	120	<10	<10
	Sept	10-12	2.24	0.7	0.9	NA	<5	13	145	<10	<10
Ga., Atlanta	July	7-16	1.50	0.5	1.1	NA	<5	21	55	<10	<10
	Aug	6-17	1.82	0.4	1.1	NA	<5	18	50	<10	<10
	Sept	5-15	1.74	0.5	1.2	NA	<5	19	65	<10	<10
Hawaii, Honolulu	July	6-10	1.82	0.4	1.1	1.0	<5	8	65	<10	<10
	Aug	15-19	1.86	0.5	1.2	0.5	<5	10	65	<10	<10
	Sept	15-19	1.74	0.4	1.3	1.3	<5	6	60	<10	<10
Idaho, Idaho Falls	July	15-17	2.12	0.7	1.6	0.5	<5	22	125	<10	<10
	Aug	16-17	1.77	0.5	1.4	0.4	<5	20	95	<10	<10
	Sept	14-17	2.07	0.6	1.7	0.2	<5	24	120	<10	<10
Ill., Chicago	July	10-12	1.75	0.8	1.5	0.6	<5	14	85	<10	<10
	Aug	11-12	1.70	0.7	1.5	0.7	<5	15	75	<10	<10
	Sept	11-14	1.85	0.7	1.5	0.7	<5	8	70	<10	<10
Ind., Indianapolis	July	4-11	1.35	0.8	1.4	0.7	<5	15	60	<10	<10
	Aug	7-16	1.84	0.7	1.6	0.7	<5	11	60	<10	<10
	Sept	15-16	1.87	0.9	1.5	0.8	<5	14	60	<10	<10
Iowa, Des Moines	July	5-12	2.06	0.8	1.1	NA	5	23	55	<10	<10
	Aug	5-13	2.37	0.8	1.1	NA	<5	19	60	<10	<10
	Sept	15-17	2.43	0.7	1.0	NA	<5	18	60	<10	<10
Kans., Wichita	July	13	1.88	0.6	1.0	NA	<5	14	30	<10	<10
	Aug	10	1.86	0.6	1.3	NA	<5	12	80	<10	<10
	Sept	12	1.92	0.7	1.3	NA	<5	17	45	<10	<10
Ky., Louisville	July	15-18	2.26	0.4	0.9	NA	5	14	40	<10	<10
	Aug	15-16	2.50	0.8	1.2	NA	<5	24	45	<10	<10
	Sept	15-17	1.98	0.7	1.1	NA	<5	19	30	<10	<10
La., New Orleans	July	12	2.59	0.6	1.3	NA	10	31	80	<10	<10
	Aug	13-15	2.63	0.6	1.1	NA	<5	26	65	<10	<10
	Sept	11-15	2.45	0.6	1.3	NA	<5	21	60	<10	<10
Maine, Portland	July	10-16	2.18	0.6	1.5	0.4	<5	21	150	<10	<10
	Aug	10-19	2.09	0.8	1.3	0.9	<5	23	130	<10	<10
	Sept	15-17	2.39	0.7	1.5	0.8	<5	15	95	<10	<10
Md., Baltimore	July	7-15	2.04	0.7	1.3	NA	<5	21	80	<10	<10
	Aug	8-15	2.12	0.7	1.1	NA	<5	18	55	<10	<10
	Sept	11-12	2.11	0.7	1.1	NA	<5	18	45	<10	<10
Mass., Boston	July	9-11	1.71	0.8	1.4	0.5	<5	18	155	<10	<10
	Aug	11-13	1.85	0.7	1.5	0.6	<5	21	125	<10	<10
	Sept	10-13	1.06	0.6	1.5	0.7	<5	14	110	<10	<10
Mich., Detroit	July	7-14	1.74	0.6	1.2	1.0	<5	11	75	<10	<10
	Aug	9-15	1.96	0.8	1.6	0.7	<5	13	90	<10	<10
	Sept	10-15	2.23	0.8	1.4	0.7	<5	8	70	<10	<10
Minn., Minneapolis	July	2-8	1.98	0.5	1.3	0.6	<5	17	75	<10	<10
	Aug	2-8	1.56	0.6	1.1	0.7	<5	17	80	<10	<10
	Sept	—	NS	NS	NS	NS	NS	NS	NS	NS	NS
Miss., Columbia	July	14-17	2.14	0.8	1.2	NA	15	34	105	<10	<10
	Aug	15-17	1.86	0.9	1.2	NA	<5	27	85	<10	<10
	Sept	12-18	1.61	0.9	1.0	NA	<5	28	65	<10	<10
Mo., St. Louis	July	8-15	2.58	0.7	1.4	0.9	5	18	50	<10	<10
	Aug	7-13	2.56	0.6	1.4	0.9	<5	17	55	<10	<10
	Sept	13-18	1.86	0.5	1.1	0.8	<5	6	55	<10	<10

TABLE 1.—INSTITUTIONAL DAILY DIETARY INTAKE CONCENTRATIONS, THIRD QUARTER 1964—Continued

Location of institution	1964	Age (years)	Total weight (kg/day)	Calcium (g/kg)	Potassium (g/kg)	Radionuclide concentrations (picocuries/kg)					
						Radium-226 [a]	Strontium-89	Strontium-90	Cesium-137	Barium-140	Iodine-131
Mont., Helena	July	7-17	1.87	0.5	1.2	0.7	<5	14	80	<10	<10
	Aug	10-16	1.80	0.4	1.0	0.6	<5	13	65	<10	<10
	Sept	17	1.97	0.3	1.1	0.6	<5	14	75	<10	<10
Nebr., Omaha	July	10-14	2.39	0.0	1.6	0.2	5	22	75	<10	<10
	Aug	10-17	1.84	0.8	1.2	0.6	5	18	50	<10	<10
	Sept	15-17	1.91	0.6	1.1	1.1	<5	21	45	<10	<10
Nev., Carson City	July	—	NS	NS	NS	NS	NS	NS	NS	NS	NS
	Aug	—	NS	NS	NS	NS	NS	NS	NS	NS	NS
	Sept	15-17	2.41	0.5	1.5	0.2	<5	23	50	<10	<10
N. J., Trenton	July	—	NS	NS	NS	NS	NS	NS	NS	NS	NS
	Aug	16	2.26	0.4	1.3	1.5	<5	16	55	<10	<10
	Sept	15	2.44	0.5	1.2	1.0	<5	9	50	<10	<10
N. Mex., Albuquerque	July	5-11	1.74	0.9	1.4	0.9	<5	14	50	<10	<10
	Aug	5-11	1.93	0.3	1.6	0.6	<5	4	50	<10	<10
	Sept	5-11	2.08	0.5	1.4	0.5	<5	8	40	<10	<10
N. Y., New York	July	—	NS	NS	NS	NS	NS	NS	NS	NS	NS
	Aug	—	NS	NS	NS	NS	NS	NS	NS	NS	NS
	Sept	—	NS	NS	NS	NS	NS	NS	NS	NS	NS
N. C., Charlotte	July	8-17	1.73	0.5	0.9	NA	<5	19	45	<10	<10
	Aug	7-14	1.88	0.6	1.0	NA	<5	26	50	<10	<10
	Sept	16-17	1.59	0.7	1.1	NA	<5	28	45	<10	<10
N. D., Fargo	July	9-16	1.70	0.9	1.4	0.1	<5	15	110	<10	<10
	Aug	10-16	1.06	1.2	1.4	2.0	<5	18	35	<10	<10
	Sept	10-12	1.44	0.6	1.6	0.6	<5	16	80	<10	<10
Ohio, Cleveland	July	6-12	2.01	0.7	1.5	0.4	<5	14	80	<10	<10
	Aug	6-12	1.82	0.6	1.8	0.7	<5	12	80	<10	<10
	Sept	10-12	1.67	0.7	1.5	0.7	<5	12	70	<10	<10
Okla., Oklahoma City	July	15-19	1.76	0.4	0.8	NA	<5	8	35	<10	<10
	Aug	12-14	2.22	0.4	0.8	NA	<5	8	20	<10	<10
	Sept	11-14	1.41	0.6	0.8	NA	<5	15	45	<10	<10
Ore., Portland	July	14-17	2.25	0.5	1.1	0.3	<5	13	55	<10	<10
	Aug	13-16	2.03	0.3	1.0	0.5	<5	12	55	<10	<10
	Sept	13-17	1.85	0.3	1.4	0.5	<5	20	70	<10	<10
Penn., Pittsburgh	July	14	2.26	0.6	1.4	0.5	<5	17	85	<10	<10
	Aug	14	2.33	0.6	1.4	0.8	<5	16	80	<10	<10
	Sept	15-16	2.06	0.6	1.4	0.7	<5	14	65	<10	<10
S. C., Charleston	July	14	1.70	0.4	1.1	NA	<5	16	55	<10	<10
	Aug	8	1.67	0.5	1.1	NA	<5	12	60	<10	<10
	Sept	10-14	1.92	0.6	1.1	NA	<5	22	75	<10	<10
Tenn., Memphis	July	14-17	1.48	0.7	1.3	NA	<5	23	40	<10	<10
	Aug	14-17	1.64	0.6	1.0	NA	<5	29	40	<10	<10
	Sept	14-17	1.64	0.6	1.0	NA	<5	20	40	<10	<10
Texas, Austin	July	13-19	2.12	0.5	1.0	NA	<5	10	35	<10	<10
	Aug	15-17	1.90	0.5	0.9	NA	<5	16	25	<10	<10
	Sept	13-15	1.97	0.5	0.9	NA	<5	11	35	<10	<10
Utah, Salt Lake City	July	—	NS	NS	NS	NS	NS	NS	NS	NS	NS
	Aug	—	NS	NS	NS	NS	NS	NS	NS	NS	NS
	Sept	16	1.85	0.5	1.5	0.6	<5	21	80	<10	<10
Vt., Burlington	July	6-16	1.47	1.0	1.5	0.9	<5	20	105	<10	<10
	Aug	7-12	1.68	0.5	1.6	0.4	<5	19	95	<10	<10
	Sept	10-12	1.55	0.5	1.6	1.8	<5	12	85	<10	<10
Va., Norfolk	July	11-17	1.20	0.5	1.2	NA	5	18	60	<10	<10
	Aug	11-15	2.27	0.5	1.0	NA	<5	16	50	<10	<10
	Sept	15-17	2.46	0.5	0.9	NA	<5	13	55	<10	<10
Wash., Seattle	July	15-17	2.46	0.7	1.5	0.6	<5	26	140	<10	<10
	Aug	15-17	2.36	0.7	1.2	1.1	<5	22	120	<10	<10
	Sept	17	2.07	0.4	1.7	0.8	<5	11	120	<10	<10
W. Va., Charleston	July	10-12	1.80	0.6	1.2	NA	<5	23	60	<10	<10
	Aug	10-12	2.08	0.5	1.0	NA	<5	23	60	<10	<10
	Sept	10-12	2.03	0.5	0.9	NA	<5	18	40	<10	<10
Wis., Milwaukee	July	5-16	1.53	0.7	1.5	0.2	<5	8	85	<10	<10
	Aug	15-17	2.67	0.6	1.4	0.7	<5	13	75	<10	<10
	Sept	15-17	2.31	0.8	1.4	0.6	<5	11	70	<10	<10
Wyo., Laramie	July	13-17	1.96	0.6	1.3	0.8	<5	20	65	<10	<10
	Aug	11-14	1.90	0.6	1.3	1.1	<5	22	60	<10	<10
	Sept	11	1.16	0.3	1.6	1.0	<5	13	55	<10	<10
Monthly averages	July		1.94	0.6	1.3	0.6	<5	17	75	<10	<10
	Aug		1.95	0.6	1.2	0.8	<5	17	70	<10	<10
	Sept		1.93	0.6	1.3	0.8	<5	18	65	<10	<10

[a] Average for radium-226 does not include total radium.
[b] NS indicates no sample.
[c] NA indicates no analysis.

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TABLE 2.—INSTITUTIONAL DAILY DIETARY INTAKE, THIRD QUARTER 1964

Location of institution	1964	Age (years)	Total weight (kg/day)	Calcium (g/day)	Potassium (g/day)	Radionuclide intakes (picocuries/day)					
						Radium-226 [a]	Strontium-89	Strontium-90	Cesium-137	Barium-140	Iodine-131
Ala., Montgomery	July	11-16	1.88	0.9	1.7	NA	10	24	95	0	0
	Aug	15-17	2.20	1.1	2.6	NA	5	26	90	0	0
	Sept	15-17	2.23	1.1	2.2	NA	5	20	110	0	0
Alaska, Palmer	July	10-16	1.60	1.0	2.4	0.6	10	38	100	0	0
	Aug	10-11	1.66	1.0	1.7	3.3	10	25	135	0	0
	Sept	11	1.63	0.5	1.8	1.1	5	26	165	0	0
Ark., Little Rock	July	7-12	1.69	0.7	2.0	NA	10	37	85	0	0
	Aug	8-12	1.68	0.8	1.8	NA	5	35	100	0	0
	Sept	10-12	1.67	1.2	1.7	NA	5	48	75	0	0
Calif., Los Angeles	July	NS	[c] NS	NS	NS	NS	NS	NS	NS	NS	NS
	Aug	—	NS	NS	NS	NS	NS	NS	NS	NS	NS
	Sept	—	NS	NS	NS	NS	NS	NS	NS	NS	NS
Colo., Denver	July	10-17	2.50	1.2	3.5	1.8	5	40	225	0	0
	Aug	10-17	2.53	1.5	3.5	3.3	15	40	175	0	0
	Sept	10-17	2.21	1.1	3.3	2.4	5	15	110	0	0
Conn., Hartford	July	1-18	1.88	1.1	2.6	1.1	5	26	170	0	0
	Aug	1-15	1.76	1.1	3.0	1.1	5	21	175	0	0
	Sept	14-19	2.04	1.2	2.9	1.0	5	20	145	0	0
Del., Wilmington	July	11-13	1.87	1.3	2.4	0.4	5	24	130	0	0
	Aug	10-12	1.23	NA	1.7	0.7	5	17	85	0	0
	Sept	11-12	1.02	1.9	4.3	1.7	5	33	135	0	0
Fla., Tampa	July	7-17	1.73	1.0	1.7	[b] NA	5	21	200	0	0
	Aug	9-16	1.81	1.1	1.6	NA	5	20	215	0	0
	Sept	10-12	2.24	1.6	2.0	NA	5	29	325	0	0
Ga., Atlanta	July	7-16	1.50	0.8	1.6	NA	5	32	80	0	0
	Aug	6-17	1.82	0.7	2.0	NA	5	33	90	0	0
	Sept	5-15	1.74	0.9	2.1	NA	5	33	115	0	0
Hawaii, Honolulu	July	6-10	1.82	0.7	2.0	1.8	5	15	120	0	0
	Aug	15-19	1.66	0.8	2.0	0.8	5	17	110	0	0
	Sept	15-19	1.74	0.7	2.3	2.3	5	10	105	0	0
Idaho, Idaho Falls	July	15-17	2.12	1.5	3.4	1.1	5	47	265	0	0
	Aug	16-17	1.77	0.9	2.5	0.7	10	35	170	0	0
	Sept	14-17	2.07	1.2	3.5	0.4	5	50	250	0	0
Ill., Chicago	July	10-12	1.75	1.4	2.6	1.1	5	24	150	0	0
	Aug	11-12	1.70	1.2	2.6	1.2	5	26	130	0	0
	Sept	11-14	1.85	1.3	2.8	1.3	5	15	130	0	0
Ind., Indianapolis	July	4-11	1.35	1.1	1.9	0.9	5	20	80	0	0
	Aug	7-16	1.84	1.3	2.9	1.3	5	20	110	0	0
	Sept	15-16	1.87	1.7	2.8	1.5	5	26	110	0	0
Iowa, Des Moines	July	5-12	2.06	1.6	2.3	NA	10	47	115	0	0
	Aug	5-13	2.37	1.9	2.6	NA	5	45	140	0	0
	Sept	15-17	2.43	1.7	2.4	NA	5	44	145	0	0
Kansas, Wichita	July	13	1.88	1.1	1.9	NA	5	26	55	0	0
	Aug	10	1.86	1.1	2.4	NA	5	22	150	0	0
	Sept	12	1.92	1.3	2.5	NA	5	33	85	0	0
Ky., Louisville	July	15-18	2.26	0.9	2.0	NA	11	32	90	0	0
	Aug	15-16	2.50	2.0	3.0	NA	5	60	113	0	0
	Sept	15-17	1.98	1.4	2.2	NA	5	38	60	0	0
La., New Orleans	July	12	2.59	1.6	3.4	NA	25	80	210	0	0
	Aug	13-15	2.63	1.6	2.9	NA	5	68	170	0	0
	Sept	11-15	2.45	1.5	3.2	NA	5	51	145	0	0
Maine, Portland	July	10-16	2.18	1.3	3.3	0.9	5	46	325	0	0
	Aug	10-19	2.09	1.7	2.7	1.9	5	48	270	0	0
	Sept	15-17	2.39	1.7	3.6	1.9	5	36	225	0	0
Md., Baltimore	July	7-15	2.04	1.4	2.7	NA	5	43	165	0	0
	Aug	8-15	2.12	1.5	2.3	NA	5	38	115	0	0
	Sept	11-12	2.11	1.5	2.3	NA	5	38	95	0	0
Mass., Boston	July	9-11	1.71	1.4	2.4	0.9	5	31	265	0	0
	Aug	11-13	1.85	1.3	2.8	1.1	5	39	230	0	0
	Sept	10-13	1.06	0.6	1.6	0.7	5	15	115	0	0
Mich., Detroit	July	7-14	1.74	1.0	2.1	1.7	5	19	130	0	0
	Aug	9-15	1.96	1.6	3.1	1.4	5	25	175	0	0
	Sept	10-15	2.23	1.8	3.1	1.6	5	18	155	0	0
Minn., Minneapolis	July	2-8	1.98	1.0	2.6	1.2	5	34	150	0	0
	Aug	2-8	1.56	0.9	1.7	1.1	5	27	125	0	0
	Sept	—	NS	NS	NS	NS	NS	NS	NS	NS	NS
Miss., Columbia	July	14-17	2.14	1.7	2.6	NA	30	73	225	0	0
	Aug	15-17	1.86	1.7	2.2	NA	5	50	160	0	0
	Sept	12-18	1.61	1.4	1.6	NA	5	45	105	0	0
Mo., St. Louis	July	8-15	2.58	1.8	3.6	2.3	15	46	130	0	0
	Aug	7-13	2.56	1.5	3.6	2.3	5	44	140	0	0
	Sept	13-18	1.86	0.9	2.0	1.4	5	11	100	0	0
Mont., Helena	July	7-17	1.87	0.9	2.2	1.3	5	26	150	0	0
	Aug	10-16	1.80	0.7	1.8	1.1	5	23	115	0	0
	Sept	17	1.97	0.6	2.2	1.2	5	28	150	0	0

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Table 2.—INSTITUTIONAL DAILY DIETARY INTAKE, THIRD QUARTER 1964—Continued

Location of institution	1964	Age (years)	Total weight (kg/day)	Calcium (g/day)	Potassium (g/day)	Radionuclide intakes (picocuries/day)					
						Radium-226 [a]	Strontium-89	Strontium-90	Cesium-137	Barium 140	Iodine-131
Nebr., Omaha	July	10–14	2.39	2.2	3.8	0.5	10	53	180	0	0
	Aug	10–17	1.84	1.5	2.2	1.1	10	33	90	0	0
	Sept	15–17	1.91	1.1	2.1	2.1	5	40	85	0	0
Nev., Carson City	July	—	NS	NS	NS	NS	NS	NS	NS	NS	NS
	Aug	—	NS	NS	NS	NS	NS	NS	NS	NS	NS
	Sept	15–17	2.41	1.2	3.6	0.5	5	55	120	0	0
N. J., Trenton	July	—	NS	NS	NS	NS	NS	NS	NS	NS	NS
	Aug	16	2.26	0.9	2.9	3.4	5	36	125	0	0
	Sept	15	2.44	1.2	2.9	2.4	5	22	120	0	0
N. Mex., Albuquerque	July	5–11	1.74	1.6	2.4	1.6	5	24	85	0	0
	Aug	5–11	1.83	0.5	2.9	1.1	5	7	90	0	0
	Sept	5–11	2.08	1.0	2.9	1.0	5	17	85	0	0
N. Y., New York	July	—	NS	NS	NS	NS	NS	NS	NS	NS	NS
	Aug	—	NS	NS	NS	NS	NS	NS	NS	NS	NS
	Sept	—	NS	NS	NS	NS	NS	NS	NS	NS	NS
N. C., Charlotte	July	8–17	1.73	0.9	1.6	NA	5	33	80	0	0
	Aug	7–14	1.88	1.1	1.9	NA	5	40	95	0	0
	Sept	16–17	1.59	1.1	1.7	NA	5	45	72	0	0
N. D., Fargo	July	9–16	1.70	1.5	2.4	0.2	5	26	185	0	0
	Aug	10–16	1.06	1.3	1.5	2.1	5	19	90	0	0
	Sept	10–12	1.44	0.9	2.3	0.9	5	23	115	0	0
Ohio, Cleveland	July	6–12	2.01	1.4	3.0	0.8	5	28	160	0	0
	Aug	6–12	1.82	1.1	3.3	1.3	5	22	145	0	0
	Sept	10–12	1.67	1.2	2.5	1.2	5	20	115	0	0
Okla., Oklahoma City	July	15–19	1.76	0.7	1.4	NA	5	14	60	0	0
	Aug	12–14	2.22	0.9	1.8	NA	5	18	45	0	0
	Sept	11–14	1.41	0.8	1.1	NA	5	21	63	0	0
Ore., Portland	July	14–17	2.25	1.1	2.5	0.7	5	29	125	0	0
	Aug	13–16	2.03	0.6	2.0	1.0	5	24	110	0	0
	Sept	13–17	1.85	0.6	2.6	0.9	5	37	130	0	0
Pa., Pittsburgh	July	14	2.26	1.4	3.2	1.1	5	38	190	0	0
	Aug	14	2.33	1.4	3.3	1.9	5	37	185	0	0
	Sept	15–16	2.06	1.2	2.9	1.4	5	29	135	0	0
S. C., Charleston	July	14	1.70	0.7	1.9	NA	5	27	95	0	0
	Aug	8	1.67	0.8	1.8	NA	5	20	100	0	0
	Sept	10–14	1.92	1.2	2.1	NA	5	42	145	0	0
Tenn., Memphis	July	14–17	1.48	1.0	1.9	NA	5	34	60	0	0
	Aug	14–17	1.64	1.0	1.6	NA	5	48	65	0	0
	Sept	14–17	1.64	1.0	1.6	NA	5	33	65	0	0
Texas, Austin	July	13–19	2.12	1.1	2.1	NA	5	21	75	0	0
	Aug	15–17	1.90	1.0	1.7	NA	5	30	50	0	0
	Sept	13–15	1.97	1.0	1.8	NA	5	22	70	0	0
Utah, Salt Lake City	July	—	NS	NS	NS	NS	NS	NS	NS	NS	NS
	Aug	—	NS	NS	NS	NS	NS	NS	NS	NS	NS
	Sept	16	1.85	0.9	2.8	1.1	5	39	150	0	0
Vt., Burlington	July	6–16	1.47	1.5	2.2	1.3	5	29	155	0	0
	Aug	7–12	1.68	0.8	2.7	0.7	5	32	160	0	0
	Sept	10–12	1.55	0.8	2.5	2.8	5	19	130	0	0
Va., Norfolk	July	11–17	2.10	1.0	2.5	NA	10	38	125	0	0
	Aug	11–15	2.27	1.1	2.3	NA	5	36	115	0	0
	Sept	15–17	2.46	1.2	2.2	NA	5	32	135	0	0
Wash., Seattle	July	15–17	2.46	1.7	3.7	1.5	5	64	345	0	0
	Aug	15–17	2.36	1.7	2.8	2.6	5	52	285	0	0
	Sept	17	2.07	0.8	3.5	1.7	5	23	250	0	0
Va., Charleston	July	10–12	1.80	1.1	2.2	NA	5	41	110	0	0
	Aug	10–12	2.08	1.0	2.1	NA	5	48	125	0	0
	Sept	10–12	2.03	1.0	1.8	NA	5	37	80	0	0
Wisc., Milwaukee	July	5–16	1.53	1.1	2.3	0.3	5	12	130	0	0
	Aug	15–17	2.67	1.6	3.7	1.9	5	35	200	0	0
	Sept	15–17	2.31	1.8	3.2	1.4	5	25	160	0	0
Wyo., Laramie	July	13–17	1.96	1.2	2.5	1.6	5	39	125	0	0
	Aug	11–14	1.90	1.1	2.5	2.1	5	42	115	0	0
	Sept	11	1.16	0.3	1.9	1.2	5	15	65	0	0
Institution Average	July		1.92	1.2	2.4	1.2	5	34	145	0	0
	Aug		1.95	1.2	2.4	1.6	5	33	135	0	0
	Sept		1.93	1.1	2.5	1.5	5	30	125	0	0

[a] Average for radium-226 does not include total radium.
[b] NS indicates no sample.
[c] NA indicates no analysis.

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Correction for March issue

Values for stable strontium are incorrectly reported in tables 2 and 3 of the article "Estimated Daily Intake of Radionuclides in California Diets," which appeared on page 154 of the March 1965 *RHD*. Table 1 is correct as given. The decimal point is misplaced in the right-hand column of both tables 2 and 3, making the stable strontium data appear too high; the decimal point should be moved one place to the left.

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Section III—Water

GROSS RADIOACTIVITY IN SURFACE WATERS OF THE UNITED STATES, OCTOBER 1964

Division of Water Supply and Pollution Control, Public Health Service

Levels of radioactivity in surface waters of the United States have been monitored by the Public Health Service Water Pollution Surveillance System since its initiation in 1957. Beginning with the establishment of 50 sampling points, this system has been expanded to 131 stations as of March 1, 1965. These are operated jointly with other Federal, State, and local agencies, and industry. Samples are taken from surface waters of all major U. S. river basins for physical, chemical, biological, and radiological analyses. These data can be used for evaluating sources of radioactivity which may affect specific domestic, commercial, and recreational uses of surface water. Further, the system provides background information necessary for recognizing pollution and water quality trends and for determining current and general levels of radioactivity to which the population may be exposed. Data assembled through the system and exact locations of sampling points are published in annual compilations (*1-7*).

Sampling procedures

The participating agencies collect one-liter "grab" samples each week and ship them "as is" to the Surveillance System Laboratory in Cincinnati for analysis. Gross alpha and gross beta radioactivity determinations on the suspended and dissolved solids are performed as frequently as deemed necessary.

Presently, gross alpha and beta determinations are made either on monthly composites of the weekly samples or on each weekly sample. Weekly alpha and beta determinations are scheduled for stations located downstream from known potential sources of radiactive waste and for other selected stations to observe short term changes due to weapons testing or other nuclear activities. Weekly analyses are also conducted at all newly established stations for the first year of operation.

Strontium-90 analyses are performed on total solids of three-month composites of the weekly samples. The most recent strontium-90 results are presented in the March 1965 issue of *RHD*.

Normally, samples are counted within two weeks following collection or within one week after compositing. The decay of activity is followed on each sample for which the first analysis shows unusually high activity. Also, if a recount indicates that the original analysis was questionable, values based on recounting are recorded. All results are reported for the time of counting and are not extrapolated to the time of collection.

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Analytical Methods

The analytical method used for determining gross alpha and beta radioactivity is described in the eleventh edition of "Standard Methods for the Examination of Water and Wastewater" (*8*). Suspended and dissolved solids are separated by passing the sample through a membrane filter (type HA) with a pore size of 0.45 micron. Planchets are then prepared for counting the dissolved solids (in the filtrate) and the suspended solids (on the charred membrane filter) in an internal proportional counter. Reference sources of U_3O_8, which give a known count rate if the instrument is performing properly, are used for daily checking of the counter.

Results

Table 1 presents October 1964 results of alpha and beta analysis of U. S. surface waters. The stations on a river are arranged in the table according to their relative location on the river, the first stations listed being closest to the headwaters. These data are preliminary. Replicate analyses of some samples as well as some analyses incomplete at the time of this report will be included in the system's "Annual Compilation of Data" (7). The figures for gross alpha and gross beta radioactivity represent either determinations on composite samples or means of weekly determinations where composites were not made. The monthly means are reported to the nearest pc/liter. When all

TABLE 1.—RADIOACTIVITY IN RAW SURFACE WATERS, OCTOBER 1964

[Average concentrations in pc/liter]

Station	Beta activity			Alpha activity		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Animas River:						
Cedar Hill, N. Mex.	3	13	16	0	2	2
Apalachicola River:						
Chattahoochee, Fla	2	4	6	<1	0	<1
Arkansas River:						
Coolidge, Kansas	2	24	26	0	23	23
Ponca City, Okla.	30	34	64	0	2	2
Atchafalaya River:						
Morgan City, La.	22	18	40	6	2	8
Bear River:						
Preston, Idaho	1	15	16	0	4	4
Big Horn River:						
Hardin, Mont	9	18	27	0	7	7
Big Sioux River:						
Sioux Falls, S. Dak.	2	24	26	0	0	0
Chattahoochee River:						
Atlanta, Ga.	6	7	13	1	0	1
Columbus, Ga.	6	6	12	1	0	1
Lanett, Ala.	9	7	16	2	0	2
Chena River:						
Fairbanks, Alaska	1	7	8	0	0	0
Clinch River:						
Clinton, Tenn.	3	12	15	1	2	3
Kingston, Tenn.	10	40	50	<1	<1	<1
Colorado River:						
Loma, Colo.	2	24	26	0	10	10
Page, Ariz.	0	24	24	0	4	4
Parker Dam, Calif-Ariz.	0	13	13	0	5	5
Columbia River:						
Wenatchee, Wash.	7	9	16	0	0	0
Pasco, Wash.	104	538	642	0	<1	<1
Clatskanie, Ore.	27	200	227	0	<1	<1
Connecticut River:						
Enfield Dam, Conn.	3	12	15	1	0	1
Coosa River:						
Rome, Ga.	20	5	25	5	0	5
Cumberland River:						
Cheatham Lock, Tenn.	0	11	11	0	0	0
Delaware River:						
Philadelphia, Pa.	1	8	9	0	0	0
Escambia River:						
Century, Fla.	4	8	12	<1	0	<1
Great Lakes:						
Duluth, Minn.	0	5	5	0	0	0
Hudson River:						
Poughkeepsie, N.Y.	2	28	30	0	0	0
Illinois River:						
Grafton, Ill.	4	15	19	1	2	3
Kansas River:						
De Soto, Kans.	13	36	49	2	2	4
Maumee River:						
Toledo, Ohio	8	18	26	1	2	3
Mississippi River:						
St. Paul, Minn.	6	26	32	0	0	0
Dubuque, Iowa	2	22	24	0	1	1
E. St. Louis, Ill.	3	18	21	2	1	3
Vicksburg, Miss.	12	27	39	3	1	4
New Roads, La.	15	18	33	2	2	4
New Orleans, La.	4	17	21	1	2	3
Missouri River:						
Williston, N. Dak.	7	21	28	1	5	6
Bismarck, N.Dak.	4	27	31	0	3	3
Yankton, S.Dak.	2	30	32	1	4	5
St. Joseph, Mo.	22	29	51	4	7	11
North Platte River:						
Henry, Nebr.	6	38	44	1	25	26
Ohio River:						
Cairo, Ill.	2	10	12	1	2	3
Toronto, Ohio	2	18	20	0	0	0
Pend Oreille River:						
Albeni Falls Dam, Idaho	0	7	7	0	1	1
Platte River:						
Plattsmouth, Nebr.	20	18	38	5	4	9
Potomac River:						
Washington, D.C.	1	12	13	1	1	2
Red River, North:						
Grand Forks, N. Dak.	5	32	37	0	2	2
Red River, South:						
Alexandria, La.	28	11	39	4	1	5
Rio Grande:						
El Paso, Tex.	8	54	62	2	10	12
Laredo, Tex.	48	20	68	9	4	13
Sacramento River:						
Greens Landing, Calif.	1	6	7	0	1	1
San Joaquin River:						
Vernalis, Calif.	9	16	25	2	12	14
San Juan River:						
Shiprock, N. Mex.	12	19	31	2	9	11
Savannah River:						
Port Wentworth, Ga.	4	13	17	<1	0	<1
Snake River:						
Wawawai, Wash.	4	11	15	0	3	3
South Platte River:						
Julesburg, Colo.	8	62	70	1	28	29
Tennessee River:						
Lenoir City, Tenn.	2	6	8	1	0	1
Chattanooga, Tenn.	2	10	12	0	0	0
Bridgeport, Ala.	4	10	14	0	1	1
Pickwick Landing, Tenn.	3	10	13	<1	<1	<1
Tombigbee River:						
Columbus, Miss.	4	6	10	<1	0	<1
Wabash River:						
New Harmony, Ind.	2	12	14	0	1	1
Yellowstone River:						
Sidney, Mont.	3	18	21	0	7	7
Maximum	104	538	642	9	28	29
Minimum	0	4	5	0	0	0

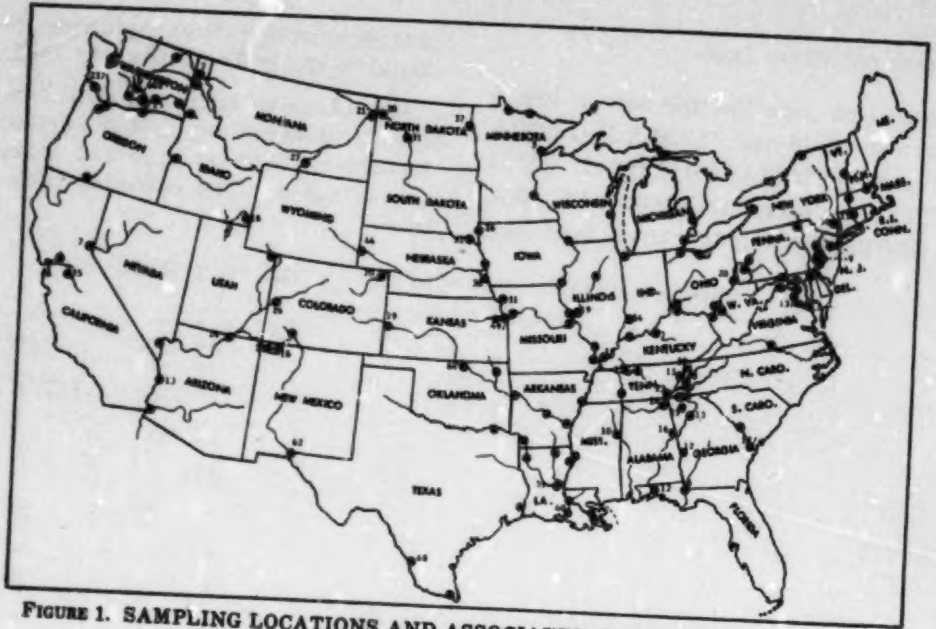
MONTANA
NORTH DAKOTA
MINNESOTA
OREGON
IDAHO
WYOMING
SOUTH DAKOTA
WISCONSIN
MICHIGAN
NEW YORK
MASS.
R.I.
CONN.
NEVADA
UTAH
NEBRASKA
IOWA
ILLINOIS
IND.
OHIO
PENNA.
N. J.
DEL.
CALIFORNIA
COLORADO
KANSAS
MISSOURI
W. VA.
VIRGINIA
KENTUCKY
ARIZONA
NEW MEXICO
OKLAHOMA
ARKANSAS
TENN.
N. CARO.
S. CARO.
MISS.
ALABAMA
GEORGIA
TEXAS
LA.
FLORIDA
ME.
VT.

FIGURE 1. SAMPLING LOCATIONS AND ASSOCIATED TOTAL BETA ACTIVITY (pc/liter) IN SURFACE WATERS, OCTOBER 1964

samples have zero pc/liter, the mean is reported as zero; when the calculated mean is between zero and 0.5 the mean is reported as<1 pc/liter.

A geographical perspective of the radioactivity in surface water is obtained from the numbers printed near the stations as shown in figure 1 which gives the October 1964 average total beta activity in suspended-plus-dissolved solids in raw water collected at each station. Gross radioactivity results for the years 1957-1962 have been summarized by Weaver *et al* (*9*).

Discussion

The monthly dissolved beta activity averages exceeded 100 pc/liter at two stations on the Columbia River; Pasco, Washington, and Clatskanie, Oregon.

Dissolved alpha activity, associated with the dissolving of natural surface minerals by water, ranged from 0 to 28 pc/liter. Of all stations, 4 stations on different rivers had monthly average dissolved alpha activity greater than 10 pc/liter.

The radioactivity associated with dissolved solids provides a rough indication of the levels which could occur in treated water, since nearly all suspended matter is removed by the treatment process (*10*). The Public Health Service Drinking Water Standards state that in the absence of strontium-90 and alpha emitters, [1] a water supply is acceptable when the gross beta concentration does not exceed 1,000 pc/liter (*11*).

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[1] Absence is taken here to mean a negligibly small fraction of the specific limits of 3 pc/liter and 10 pc/liter for unidentified alpha emitters and strontium-90 respectively.

[2] Single free copies of this publication may be obtained from: Public Inquiries Branch, Public Health Service, U. S. Department of Health, Education, and Welfare, Washington, D.C. 20201.

Corrections for March Issue

In figure 1 on page 156, the date in title is incorrect and should read, "SAMPLING LOCATIONS and ASSOCIATED TOTAL BETA ACTIVITY (pc/liter) IN SURFACE WATERS, SEPTEMBER 1964"; the date of June 1964 in column 1 of text referring to figure 1 should be changed to September 1964.

The column of figures on right hand side of table 1, "Radioactivity in Raw Surface Waters, September 1964" on page 157 contains misaligned values. The corrected table appears below.

TABLE 1.—RADIOACTIVITY IN RAW SURFACE WATERS, SEPTEMBER 1964

[Average concentrations in pc/liter]

Station	Beta activity			Alpha activity		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Animas River:						
Cedar Hill, N. Mex.	4	14	18	1	1	2
Apalachicola River:						
Chattahoochee, Fla.	2	2	4	0	0	0
Arkansas River:						
Coolidge, Kansas	6	43	49	0	12	12
Ponca City, Okla.	53	31	84	9	0	9
Atchafalaya River:						
Morgan City, La.	7	16	23	0	1	1
Bear River:						
Preston, Idaho	0	8	8	0	2	2
Big Horn River:						
Hardin, Mont	7	9	16	1	10	11
Chattahoochee River:						
Atlanta, Ga	5	9	14	<1	0	<1
Columbus, Ga	2	7	9	0	0	0
Lanett, Ala	2	4	6	0	0	0
Chena River:						
Fairbanks, Alaska	1	8	9	0	1	1
Clinch River:						
Clinton, Tenn	0	7	7	0	0	0
Kingston, Tenn	12	23	35	0	0	0
Colorado River:						
Loma, Colo	4	0	4	1	17	18
Page, Ariz	1	34	35	0	5	5
Parker Dam, Calif-Ariz	1	19	20	0	10	10
Columbia River:						
Wenatchee, Wash	0	11	11	0	0	0
Pasco, Wash	123	981	1104	0	1	1
Clatskanie, Ore	18	150	168	<1	<1	<1
Connecticut River:						
Enfield Dam, Conn.	0	9	9	0	0	0
Cumberland River:						
Cheatham Lock, Tenn	0	8	8	0	0	0
Delaware River:						
Philadelphia, Pa	1	7	8	0	0	0
Escambia River:						
Century, Fla	5	8	13	1	0	1
Great Lakes:						
Duluth, Minn	0	1	1	0	0	0
Hudson River:						
Poughkeepsie, N.Y.	4	13	17	0	0	0
Illinois River:						
Grafton, Ill	6	17	23	1	2	3
Kansas River:						
De Soto, Kans	51	33	84	7	1	8
Maumee River:						
Toledo, Ohio	4	18	22	1	1	2
Mississippi River:						
St. Paul, Minn	1	27	28	0	2	2
E. St. Louis, Ill	8	19	27	1	2	3
Vicksburg, Miss	13	22	35	2	1	3
New Roads, La	11	19	30	1	1	2
New Orleans, La	0	16	16	0	1	1
Missouri River:						
Williston, N. Dak	5	22	27	0	4	4
St. Joseph, Mo	34	31	65	10	4	14
North Platte River:						
Henry, Nebr	3	34	37	0	21	21
Ohio River:						
Cairo, Ill	0	6	6	0	1	1
Toronto, Ohio	2	16	18	0	0	0
Platte River:						
Plattsmouth, Nebr	58	22	80	12	3	15
Potomac River:						
Washington, D.C	2	11	13	0	0	0
Red River, North:						
Grand Forks, N. Dak	2	30	32	0	1	1
Red River, South:						
Alexandria, La	13	20	33	2	1	3
Rio Grande:						
El Paso, Tex	96	29	125	25	0	25
Laredo, Tex	418	16	434	73	1	74
San Joaquin River:						
Vernalis, Calif	6	24	30	1	7	8
San Juan River:						
Shiprock, N. Mex	855	26	881	264	6	270
Savannah River:						
Port Wentworth, Ga	5	13	18	0	0	0
Snake River:						
Wawawai, Wash	3	11	14	0	2	2
South Platte River:						
Julesburg, Colo	3	51	54	0	18	18
Susquehanna River:						
Conowingo, Md	2	9	11	0	0	0
Tennessee River:						
Lenoir City, Tenn	1	7	8	0	0	0
Chattanooga, Tenn	2	10	12	0	<1	<1
Bridgeport, Ala	0	14	14	1	0	1
Pickwick Landing, Tenn	2	11	13	0	<1	<1
Tombigbee River:						
Columbus, Miss	3	8	11	0	0	0
Wabash River:						
New Harmony, Ind	8	13	21	0	<1	<1
Yellowstone River:						
Sidney, Mont	25	18	43	3	3	6
Maximum	855	981	1104	264	21	270
Minimum	0	0	1	0	0	0

Note: These data are preliminary: reanalysis of some samples may be made and additional analysis not completed at the time of the report may become available. For final data, one should consult the system's annual report.

Section IV—Other Data

CESIUM-137 BURDENS IN MAN, JULY 1963 THROUGH AUGUST 1964[1]

Frank C. Leitnaker, Richard C. Reba, and Kent T. Woodward[2]

Whole body cesium-137 burdens have been determined periodically by liquid-scintillation whole-body counting at the Walter Reed Army Institute of Research (WRAIR) since 1957 (*1, 2*). This paper concerns the data obtained from July 1963 through August 1964.

Procedure

During this period 690 assays of 628 subjects were done, with each determination based on a 200-second counting time. Subjects were primarily active duty military personnel (general population). Those subjects having radioisotope contact were carefully noted. Cesium-137 body burdens are expressed as "picocuries cesium-137 per gram potassium" (pc Cs^{137}/g K). The precision of the measurement is illustrated by 14 separate determinations on the same subject over an eight-month period. With a mean body burden of 13.0 nc or 78.21 pc/g K, the standard deviation was 4.5 percent with a standard error of 1.2 percent. Thus, the 95 percent confidence limits for the precision of any individual cesium-137 burden determined in the routine manner should be about ±1.2 nc.

Results

Human burdens were found to be other than normally distributed (figure 1). The distribution of pc Cs^{137}/g K for all subjects counted in July and August 1964, as well as for subjects counted over the entire period, approximates a log-normal distribution (straight line fit on log probability paper—figure 2). Ellett and Brownell (*3*) have found that their data (cesium-137/g muscle) best fit a gamma distribution. These data will be submitted to goodness of fit testing for normal, log normal, and gamma distributions. The skewness of the Walter Reed population distribution is not extreme and other workers have generally assumed similar distributions for the same kinds of data to be normal (*2, 4, 5*). The main error in this assumption has been in estimating expected numbers in the population which would exceed three times the mean values. Differences between the arithmetical and geometrical means of each population are small. Since no rigorous statistical analysis is presented at this time, the data are expressed in the usual statistical parameters of arithmetical mean and standard deviation.

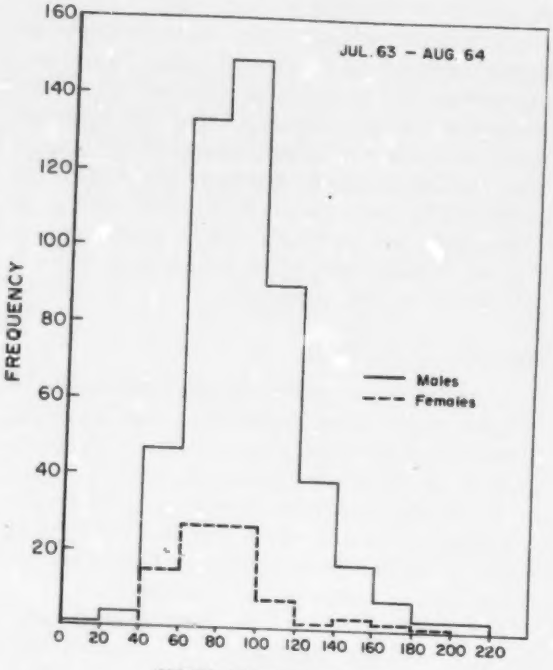

FIGURE 1. FREQUENCY DISTRIBUTION OF THE WALTER REED POPULATION

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[1] This study was supported in part by Defense Atomic Support Agency contract RD 41-61, Subtask 03.083.

[2] Dr. Leitnaker is Research Fellow in Radiation Biology (Isotope Metabolism), Dr. Reba is Chief of the Department of Isotope Metabolism, and Dr. Woodward is Director of the Division of Nuclear Medicine, Walter Reed Army Institute of Research, Washington, D.C.

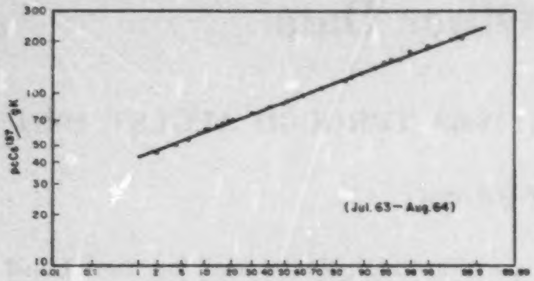

FIGURE 2. CUMULATIVE DISTRIBUTION OF CESIUM-137/POTASSIUM, U.S.A. AND EUROPE ADULT POPULATIONS, JULY 1963–AUGUST 1964

Total body potassium for each subject was also determined. Since the calculations assume no source of gamma radioactivity in the subject other than cesium-137 and potassium-40, contamination with other gamma emitters tends to produce erroneous results for one or both values. Depending on the energy of the contaminant, either or both values can be raised, or one raised and the other lowered. Actually, any contaminant (except ones which would exactly simulate either cesium-137 or potassium-40 in energy) would affect both values if it affected either. Thus, definitely contaminated subjects can be identified by highly deviant potassium values. However, application of Chauvenet's criterion (*6*) to the potassium values identified only 19 contaminated subjects previously identified by crystal spectroscopy, previous exposure and history of radionuclide exposure. With these subjects eliminated, age, sex and radionuclide contact seemed to make very little difference in the recalculated means (table 1).

Analysis of the Data

Accordingly, all data from the remaining 609 subjects have been recombined and analyzed by month of analysis. Figure 3 shows the mean pc Cs^{137}/g K ratios by month with a range of two standard errors. The 33 percent rise to a maximum in the early summer of 1964 is definite. There was no change in the potassium determinations during this period.

TABLE 1.—CESIUM-137 LEVELS BY AGE, SEX AND RADIOLOGICAL EXPOSURE, JULY 1963-AUGUST 1964

Age range	Sex	Rad. exp.	Av. age	Number of subjects	Cs pc/g K	Standard error
0-9	F	−	6	8	80.33	7.08
10-19	M	−	16	19	89.90	5.56
		[a] +	19	2	167.17	39.40
	F	−	17	19	86.56	6.06
		+	19	2	74.34	9.38
20-29	M	−	24	144	92.83	2.65
		+	26	96	92.09	2.94
	F	−	23	28	75.29	3.46
		+	26	5	79.74	9.89
30-39	M	−	33	57	90.70	4.25
		+	34	105	93.36	2.38
	F	−	32	5	93.84	9.58
		+	35	7	88.84	7.05
40-49	M	−	44	18	97.84	10.05
		+	43	41	82.02	3.46
	F	−	45	11	82.53	10.90
		+	44	7	112.02	11.30
50-59	M	−	55	3	76.97	15.50
		+	54	10	92.01	6.27
	F	−	54	3	95.73	25.85
		+	53	3	73.01	7.50
60-69	M	+	62	3	81.29	11.91
	F	+	64	1	81.37	

[a] Plus sign indicates that subjects handled radioactive materials but were not contaminated.

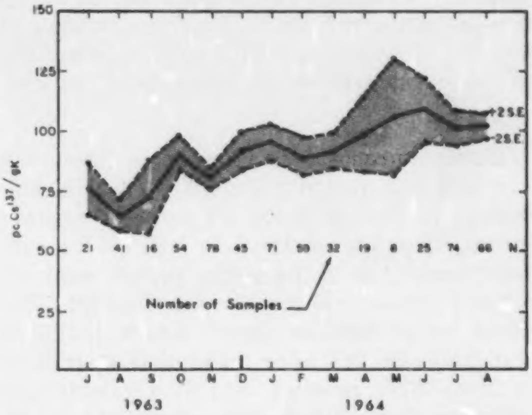

FIGURE 3. MEAN CESIUM-137 BURDENS IN WRAIR POPULATION SAMPLE FROM JULY 1963 TO AUGUST 1964

The State and major geographical area (U.S., Far East, Europe, *etc.*) in which each subject had lived the longest during the previous 30 months was recorded. Maryland, the District of Columbia, and Virginia represented 43 percent of all subjects reported. Cesium-137 levels in those residing primarily in the U.S. during the last 30 months have been compared with those living in other areas (table 2). The data are, in general, too few for meaningful comparison except that the mean of cesium-137 of the group from Europe (primarily Germany) appears to be about 30 percent higher than that of U.S. subjects. Different nationalities of people are not being compared, but groups of Americans living at home and abroad are. Although much of the American diet eaten by military personnel in Europe consists of food shipped from the United States, European sources provide most of the dairy products, meat, and fresh vegetables.

TABLE 2.—HUMAN BURDENS OF CESIUM-137 BY AREA OF RESIDENCE, JULY 1963–AUGUST 1964

Area	Number of subjects	Cesium-137 (pc/g K) mean & one St'd error
Far East		
Near East	34	78.16±4.80
Asia	1	62.41
Europe	2	82.34±3.25
Africa	66	114.49±4.90
Caribbean	1	53.78
Central America	3	73.38±8.90
U.S.A.	1	91.60
	499	88.97±1.62

An attempt to reveal time variations in cesium-137 levels by State was not feasible. To define real differences would require much larger sample sizes. To help achieve this, and in the hope that some combination would be more meaningful, the U.S. was divided into six arbitrary areas (figure 4). To increase the sample size further, combination into three areas was made when it was noted that each group had a mean pc Cs^{137}/g K value almost identical with an adjacent group. Mean values by month for paired areas also tended to rise and fall together.

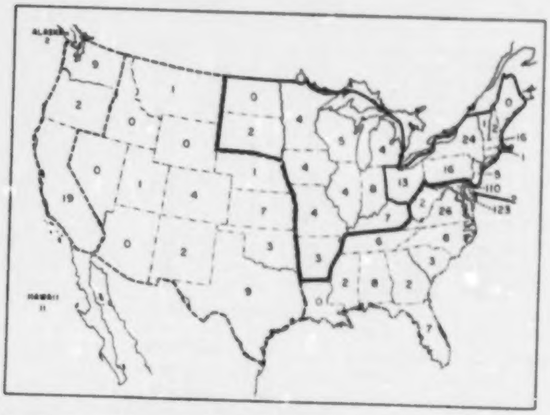

FIGURE 4. U.S. SUBJECTS COUNTED BY STATE

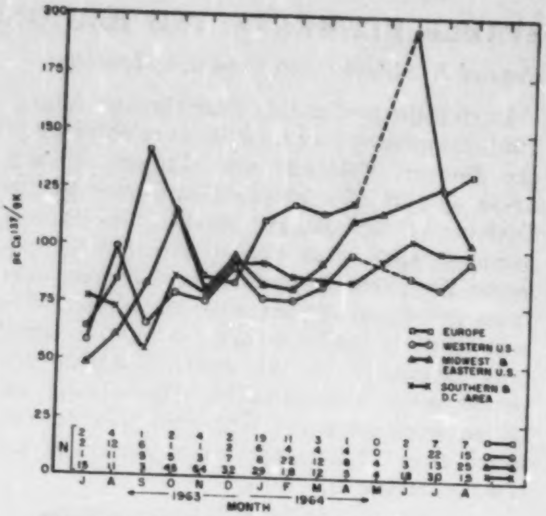

FIGURE 5. MONTHLY MEAN CESIUM-137 BURDENS BY AREA

Although these combined areas may not really be homogeneous, the data suggest that there is not much difference between them. Figure 5 compares the mean monthly cesium-137 levels of the three large U.S. areas with those from Europe. The number of subjects, N, which determined each point is given. Although not noted on the graph, there was a large uncertainty of many points, due, it is felt, to small sample size. It appears that the "European burdens" were little, if any, higher than those in the U.S. until after the beginning of 1964. Increases in the U.S. level seemed to lag behind those from Europe.

Acknowledgments

The authors wish to thank Dr. Daniel Bruce and the Data Processing and Mathematics Section of the Division of Radiological Health, Public Health Service, for assistance.

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STABLE ELEMENTS AND RADIONUCLIDES IN HUMAN MILK

Conrad P. Straub [1] and *Gopala K. Murthy* [2]

During the period July 1959 through August 1961, samples of human milk were obtained in the Denver, Colorado and Chicago, Illinois areas as part of a program supported by the Division of Radiological Health. The Denver samples represented pooled human milk collected postpartum; those from Chicago were from individual donors who contributed to a milk bank. In the latter area, samples of cows' milk consumed by the mothers during the period were also collected. The results obtained were compared with milk samples collected from an area serving a portion of the Chicago milkshed.

The individual values are presented in tables 1 through 4. Table 1 lists the results obtained with the Denver human milk samples; table 2, the Chicago human milk samples; table 3, the Chicago cows' milk samples consumed by the donors; and table 4, the Chicago raw milkshed samples.

All data shown are expressed as the geometric mean and standard deviation ($M_g \overset{\times}{\div} \sigma_g$), the arithmetic mean ($\overline{M}$), and the median values (M_d). The results show that the human milk values in Denver and Chicago had respective geometric mean values of $0.24 \overset{\times}{\div} 1.28$ and $0.21 \overset{\times}{\div} 1.26$ g calcium/liter, $0.62 \overset{\times}{\div} 1.16$ and $0.32 \overset{\times}{\div} 1.18$ g potassium/liter, $0.62 \overset{\times}{\div} 1.55$ and $0.56 \overset{\times}{\div} 1.56$ pc/liter of strontium-90, and $2.52 \overset{\times}{\div} 1.73$ and $2.73 \overset{\times}{\div} 1.82$ pc strontium-90/g calcium. In addition, values for cesium-137 are shown. With the exception of the potassium concentrations, there is excellent agreement in the values reported for the two areas. The potassium difference is believed to be due to the nature of the human milk collected. The Denver samples were pooled from postpartum donors, whereas the Chicago samples were received from individual donors whose milk was obtained during later lactation stages. The values cited above may be compared with values for cows' milk as given in tables 3 and 4.

In a paper submitted for publication elsewhere (*1*), the data listed are compared with concentrations found in human milk by other authors.

REFERENCE

(*1*) Straub, Conrad P. and Gopala K. Murthy. Radionuclides in Human Milk. Submitted to *Pediatrics*.

TABLE 1.—CALCIUM, POTASSIUM, AND RADIONUCLIDE CONCENTRATIONS IN HUMAN MILK, DENVER, COLORADO

Sample number	Date	Ca (g/liter)	K (g/liter)	Sr^{90} (pc/liter)	Cs^{137} (pc/liter)	Sr^{90}/Ca (pc/g)
1	7/9/59	0.185	0.552	[a] 0.7 ±0.6	[a, b] 11 ±1.3	3.8
2	7/17/59	0.220	0.561	0.7 ±0.6	[c] —	3.2
3	11/5/59	0.212	0.664	0.2 ±0.4	—	0.9
4	11/16/59	0.227	0.643	0.4 ±0.6	19	1.8
5	11/27/59	0.293	0.618	0.4 ±0.6	17	1.4
6	12/16/59	0.277	0.712	0.6 ±0.4	15	2.2
7	1/8/60	0.277	0.707	0.5 ±0.4	5	1.8
8	1/18/60	0.358	0.777	0.6 ±0.4	15	1.7
9	1/19/60	0.183	0.630	0.6 ±0.4	15	3.2
10	3/14/60	0.252	0.674	0.7 ±0.4	[d] ND	2.8
11	3/16/60	0.218	0.658	0.8 ±0.4	ND	3.7
12	5/6/60	0.198	0.508	0.8 ±0.4	18	4.0
13	8/1/60	0.126	0.271	1.2 ±0.7	10	9.5
14	10/17/60	0.268	0.681	0.49 ±0.6	ND	1.8
15	12/60	0.275	0.563	1.10 ±0.3	5	4.0
16	2/61	0.228	0.567	0.84 ±0.4	10	3.7
Arith. average, $\overline{M}$		0.237	0.611	0.67		3.1
Geom. average, $M_g \overset{\times}{\div} \sigma_g$		$0.24 \overset{\times}{\div} 1.28$	$0.62 \overset{\times}{\div} 1.16$	$0.62 \overset{\times}{\div} 1.55$		$2.52 \overset{\times}{\div} 1.73$
Median, M_d		0.228	0.636	0.65		3.0

[a] Two σ counting error.
[b] By radiochemistry.
[c] —, no value available.
[d] ND indicates not detectable.

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TABLE 2.—CALCIUM, POTASSIUM, AND RADIONUCLIDE CONCENTRATIONS IN HUMAN MILK, CHICAGO, ILLINOIS

Sample number	Date [a]	Ca (g/liter)	K (g/liter)	Sr^{90} (pc/liter)	Cs^{137} (pc/liter)	Sr^{90}/Ca (pc/g)
1	12/21/59	0.293	0.508	[b]0.6 ±0.4	5	2.0
2	12/29/59	0.198	0.329	0.4 ±0.2	10	3.0
3	1/25/60	0.191	0.534	0.3 ±0.2	10	1.6
4	5/19/60	0.190	0.344	1.4 ±0.8	[c] ND	7.4
5	6/13/60	0.231	0.251	0.6 ±0.4	10	2.6
6	(6/60) 7/12/60	0.191	0.306	0.74±0.6	10	3.9
7	(7/60) 8/5/60	0.126	0.271	0.70±0.4	ND	5.6
8	(8/60) 9/12/60	0.162	0.290	0.95±0.4	ND	5.8
9	(9/60) 10/11/60	0.219	0.334	0.50±0.3	ND	2.3
10	(10/60)	0.215	0.269	0.66±0.6	10	3.1
11	(11/60)	0.301	0.307	0.66±0.4	ND	2.2
12	(12/60)	0.192	0.258	0.78±0.1	ND	4.1
13	(1/61)	0.178	0.339	0.88±0.2	ND	4.9
14	(2/61)	0.216	0.379	0.5 ±0.4	10	2.3
15	(3/61)	0.282	0.340	0.3 ±0.4	5	1.1
16	(4/61)	0.245	0.346	0.5 ±0.4	5	2.0
17	(5/61)	[d] —	—	0.67	—	—
18	(6/61)	0.228	0.312	0.42	—	1.8
19	(7/61)	—	—	0.25	—	—
20	(8/61)	0.205	0.340	0.32	—	1.6
Arith average, $\overline{M}$		0.215	0.336	0.61	4	3.2
Geom average, $M_g \overset{\times}{\underset{+}{}} \sigma_g$		$0.21 \overset{\times}{\underset{+}{}} 1.26$	$0.32 \overset{\times}{\underset{+}{}} 1.18$	$0.56 \overset{\times}{\underset{+}{}} 1.56$		$2.73 \overset{\times}{\underset{+}{}} 1.82$
Median, M_d		0.211	0.332	0.6		2.4

[a] Dates in parentheses indicate month of collection; other dates indicate when samples were received.
[b] Two-sigma counting error.
[c] ND indicates not detectable.
[d] Dashes indicate no values available.

TABLE 3.—CALCIUM, POTASSIUM, AND RADIONUCLIDE CONCENTRATIONS IN COWS' MILK, CONSUMED BY TEST SUBJECTS, CHICAGO, ILLINOIS

Sample number	Date [a]	Ca (g/liter)	K (g/liter)	Sr-90 [b] (pc/liter)	Cs-137 (pc/liter)	Sr-90/Ca (pc/g)	Observed ratio [c]
1	(11/60)	1.112	1.464	6.9±1.6	10	6.2	0.35
2	(12/60)	1.127	1.432	6.6±1.4	5	5.9	0.70
3	(1/61)	1.172	1.452	6.5±2.4	25	5.5	0.89
4	(2/61)	1.125	1.441	10.0±1.8	5	8.9	0.26
5	(3/61)	1.096	1.415	6.6±1.2	20	6.0	0.18
6	(4/61)	1.135	1.393	7.6±1.6	25	6.7	0.30
7	(5/61)	[d] —	—	5.6	—		
8	(6/61)	1.056	1.376	5.9	—	5.6	0.32
9	(7/61)	—	—	5.0	—		
10	(8/61)	1.068	1.394	4.4	—	4.1	0.39
Arith average, $\overline{M}$		1.111	1.421	6.5		6.1	0.42
Geom average, $M_g \overset{\times}{\underset{+}{}} \sigma_g$		$1.12 \overset{\times}{\underset{+}{}} 1.05$	$1.42 \overset{\times}{\underset{+}{}} 1.03$	$6.35 \overset{\times}{\underset{+}{}} 1.22$	$13 \overset{\times}{\underset{+}{}} 2.7$	$6.05 \overset{\times}{\underset{+}{}} 1.15$	$0.39 \overset{\times}{\underset{+}{}} 2.0$
Median, M_d		1.118	1.424	6.6	15	6.0	0.37

[a] Dates in parentheses are months of collection; other dates indicate when samples were received.
[b] Two-sigma counting error.
[c] Observed ratio $= \frac{(Sr^{90}/Ca)_h}{(Sr^{90}/Ca)_c}$; i.e., human milk to cows' milk.
[d] Dash indicates no value available.

TABLE 4.—CALCIUM, POTASSIUM, AND RADIONUCLIDE CONCENTRATIONS IN COWS' MILK, CHICAGO RAW MILKSHED SAMPLES

Sample number	Date	Ca (g/liter)	K (g/liter)	Sr-90 (pc/liter)	Cs-137 (pc/liter)	Sr-90/Ca (pc/g)
1	11/60	1.19	1.44	7.7 ±0.5	15	6.5
2	12/60	1.10	1.42	8.1 ±0.8	15	7.4
3	1/61	1.16	1.45	3.5 ±0.4	15	3.0
4	2/61	1.20	1.52	5.7 ±0.6	20	4.8
5	3/61	1.15	1.54	8.4 ±0.6	20	7.3
6	4/61	1.14	1.42	9.0 ±0.7	15	7.9
7	5/61	1.13	1.43	7.5 ±0.5	25	6.6
8	6/61	1.11	1.45	5.0 ±0.6	25	4.5
9	7/61	1.10	1.41	4.8 ±0.6	10	4.4
10	8/61	1.12	1.48	6.8 ±1.1	10	6.1
Arith average, $\overline{M}$		1.14	1.46	6.6	17	5.8
Geom average, $M_g \overset{\times}{\underset{+}{}} \sigma_g$		$1.13 \overset{\times}{\underset{+}{}} 1.04$	$1.44 \overset{\times}{\underset{+}{}} 1.02$	$6.6 \overset{\times}{\underset{+}{}} 1.48$	$16 \overset{\times}{\underset{+}{}} 1.53$	$5.8 \overset{\times}{\underset{+}{}} 1.37$
Median, M_d		1.14	1.44	7.2	15	6.3

ENVIRONMENTAL LEVELS OF RADIOACTIVITY AT ATOMIC ENERGY COMMISSION INSTALLATIONS

Atomic Energy Commission contractors who handle or produce radioactive materials are required to report periodically to the Commission on the environmental levels of radioactivity in the vicinity of major installations. These reports include data from routine monitoring programs where operations are of such a nature that plant perimeter surveys are required.

Summaries of the environmental radioactivity reports for selected AEC installations are regularly published in *Radiological Health Data*. Summaries appearing in this issue cover the monitoring programs during the first half of 1964 at the following installations: Bettis Atomic Power Laboratory, Knolls Atomic Power Laboratory, Feed Materials Production Center, and the S1C Prototype Reactor Facility.

Releases of radioactive materials from these installations for the periods covered in the reports below are governed by standards set fourth in appropriate chapters of the AEC manual. The radioactivity concentration limits applicable to effluents released from AEC installations are identical to those published in the Federal Register (*1*).

1. Bettis Atomic Power Laboratory[1]
January–June 1964

Westinghouse Electric Corporation
Pittsburgh, Pennsylvania

The Bettis Atomic Power Laboratory (BAPL) operated for the Atomic Energy Commission by Westinghouse Electric Corporation, was established in 1949 to conduct research and development operations related to naval atomic propulsion systems and the central station atomic power reactor at Shippingport, Pennsylvania.

Routine environmental monitoring data from the sampling locations shown in figure 1 indicate that environmental radiation concentrations resulting from laboratory operations are well within Atomic Energy Commission prescribed limits (*1*).

Liquid radioactive waste

Liquid effluent discharged from the Laboratory is sampled continuously, and composite samples are analyzed weekly for gross alpha and gross beta-gamma activity and quarterly for strontium-90 activity. In addition, analysis for total uranium alpha activity is performed whenever the combined gross alpha activity exceeds 2,000 pc/liter.

The average concentration of gross radioactivity, including fallout, in the liquid effluent during the first six months of 1964 was 53 pc/liter. This represents a decrease from the 130 pc/liter average concentration observed in the first half of 1963. The average concentration of strontium-90 for the fourth quarter of 1963 was 4.0 pc/liter. The average concentration of strontium-90 for the first quarter of 1964 was 5.4 pc/liter.

The strontium-90 analyses for the second quarter 1964 have not been completed.

Background monitoring stations

Four background monitoring stations are in continuous operation on the Laboratory property. Three of the stations are located at the perimeter of the Laboratory and one station is centrally located with respect to the main Laboratory area. These stations continually measure and record the external beta-gamma radiation level, the external gamma radiation level and the beta-gamma activity of particulates in air as collected by a continuous air monitor of the moving filter type. Air samples are continuously collected at two of the stations. The filters removed from the high volume air samplers are retained for specific analysis when required to identify the nature of the airborne activity. External gamma activity for the three perimeter stations is given in table 1.

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[1] Data and information summarized from reports to the Pennsylvania Department of Health entitled *Environmental Radioactivity at the Bettis Atomic Power Laboratory PNRO–DEV–*^{130}. The reports were prepared by BAPL's Industrial Hygiene Department and transmitted through the AEC Pittsburgh Naval Radiation Office (July 20, 1964).

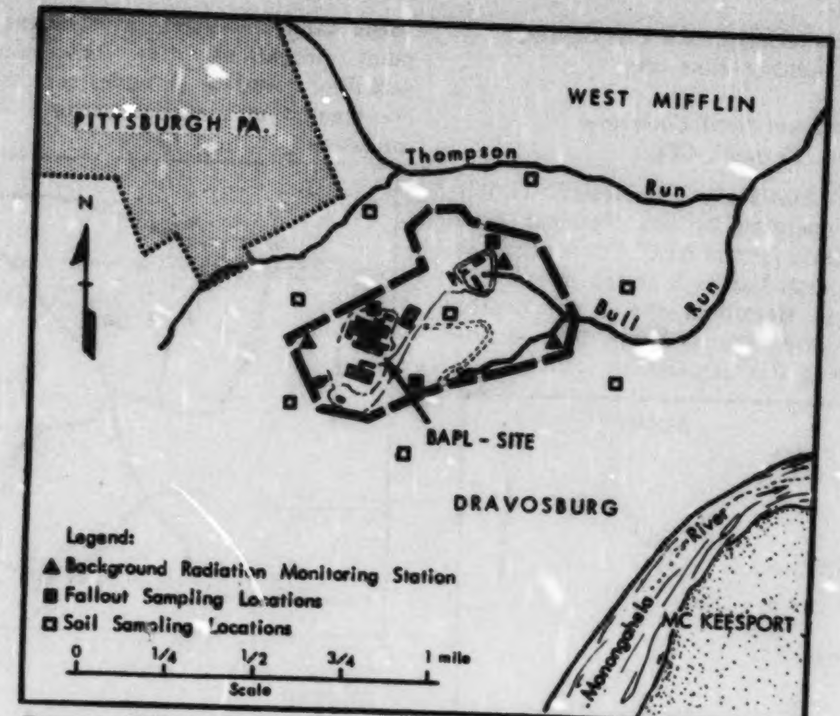
PITTSBURGH PA.
WEST MIFFLIN
N
Thompson Run
Bull Run
BAPL - SITE
DRAVOSBURG
Monongahela River
MC KEESPORT
Legend:
▲ Background Radiation Monitoring Station
■ Fallout Sampling Locations
□ Soil Sampling Locations
0
1/4
1/2
3/4
1 mile
Scale

FIGURE 1. BETTIS ATOMIC POWER LABORATORY SAMPLING STATIONS

TABLE 1.—RADIOACTIVITY IN THE BAPL ENVIRONMENT, JANUARY-JUNE 1964

Type of measurement	First quarter	Second quarter
Liquid wastes (pc/liter)		
Gross activity[a]	[b] —	53
Strontium-90	5.4	[c] —
Beta-gamma dose rate (mrad/hr)	[b] —	0.016
Beta activity in fallout (mc/mi²/mo)	[b] —	[c, d] 15.7
Stream silt (pc/gram)		
Alpha: Station A	33	19
Station B	31	20
Station C	26	18
Beta: Station A	46	18
Station B	25	29
Station C	27	37

[a] An environmental MPC of 2000 pc/liter is used as the standard for liquid waste effluent.

[b] Semi-annual average.

[c] Second quarter results not complete.

[d] Five months (through May) average for all stations.

Background beta-gamma radiation intensities averaged 0.016 mr/hr during this period. This is not significantly different from the background radiation intensities measured previously at the same location.

Stream silt

Stream silt sampling previously reported has now been discontinued.

Soil samples

Soil samples are collected at eight locations on and offsite and are retained for a period of two years. These samples are analyzed for radioactivity only on an "as required" basis. No analyses were required during the six-month period.

Fallout

Fallout samples, collected at three locations at the perimeter of the Laboratory over a period of one month in high-wall stainless steel pots, are analyzed for gross alpha activity and gross beta-gamma activity.

The average concentration of radioactive fallout for five months during the first half of 1964 was 15.7 mc/mi²/mo. (The analyses of samples for the month of June were incomplete at the time of reporting.) There was a decrease in fallout activity during this period as compared to the first six months of 1963.

Recent coverage in *Radiological Health Data:*

Period	Issue
July 1961 to June 1962	*April 1963*
July 1962 to June 1963	*April 1964*
July 1963 to December 1963	*November 1964*

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2. Feed Materials Production Center, January–June 1964

National Lead Company
Fernald, Ohio

The Feed Materials Production Center (FMPC) is operated by the National Lead Company of Ohio for the AEC. The location as related to populated areas is shown in figure 2. Cincinnati and Hamilton—the larger nearby communities—are situated 20 and 10 miles, respectively, from the Center.

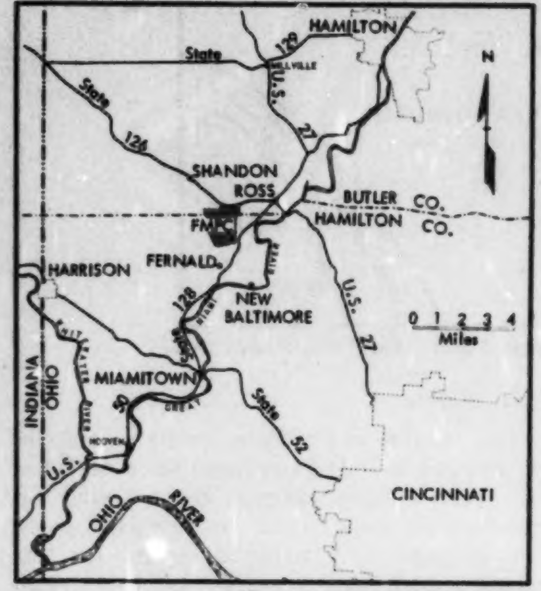
HAMILTON
State
129
BELLVILLE
U.S.
27
N
State
126
SHANDON
ROSS
BUTLER CO.
HAMILTON CO.
FMPC
FERNALD
HARRISON
128
NEW BALTIMORE
U.S.
27
0 1 2 3 4
Miles
INDIANA
OHIO
MIAMITOWN
GREAT
State
52
U.S.
CINCINNATI
OHIO
RIVER

FIGURE 2. AREA MAP OF FEED MATERIALS PRODUCTION CENTER

Operations at this project deal with processing of high-grade uranium concentrates to produce metallic uranium and with fabricating the metal into fuel elements.

An environmental survey program of air and water sampling is maintained to check the effectiveness of dust collectors and waste treatment processes. Inspection of the data indicates that the release of radioactive materials to the environment is controlled as required by AEC and State of Ohio regulations.

Air monitoring

FMPC uses dust collectors such as bag collectors, electrostatic precipitators, and scrubbing towers which remove nearly all of the airborne particulates generated during the many plant operations. The environmental air sampling program provides an indication of the amount of material released into the atmosphere.

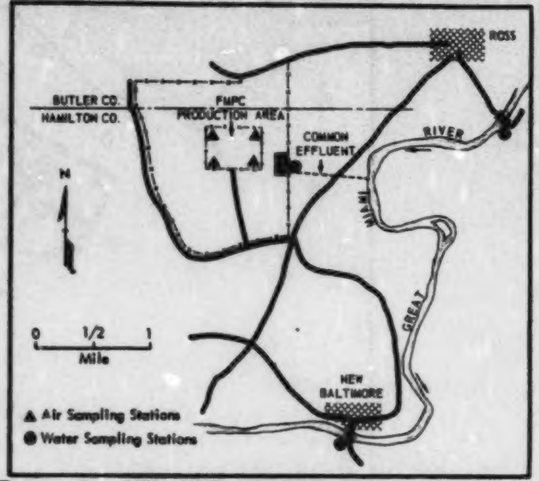
ROSS
BUTLER CO.
HAMILTON CO.
FMPC
PRODUCTION AREA
COMMON
EFFLUENT
RIVER
N
MIAMI
GREAT
0 1/2 1
Mile
NEW
BALTIMORE
▲ Air Sampling Stations
● Water Sampling Stations

FIGURE 3. AIR AND WATER SAMPLING STATIONS, FEED MATERIALS PRODUCTION CENTER

Onsite samples were taken at four permanent sampling stations located at the four corners of the production area shown in figure 3. Offsite samples were taken by a mobile unit operated at various distances and directions from the plant determined by local meteorological conditions on the day of sampling. The data for the offsite samples are averaged in groups according to distance from the production area. Concentrations of uranium and total activity of airborne particulates sampled at onsite and offsite locations are given in table 2.

TABLE 2.—RADIOACTIVITY OF AIRBORNE PARTICULATES, FMPC

[Average concentrations in pc/m³]

Location	First half 1964		
	No. of samples	Uranium [a]	Total activity [b]
Onsite			
Southwest	25	0.2	1.3
Northwest	24	0.1	1.1
Northeast	25	0.3	1.6
Southeast	24	0.2	1.2
All onsite samples	98	0.2	1.3
Offsite			
0–2 miles from FMPC	34	0.2	1.4
2–4 miles from FMPC	24	0.1	1.0
4–8 miles from FMPC	38	0.1	1.3
8–10 miles from FMPC	10	0.1	1.1
All offsite samples	116	0.1	1.2

[a] MPC = 2 pc/m³
[b] MPC = 100 pc/m³

Water monitoring

Continuous daily samples, collected from the combined sewer leading from the FMPC site to the Great Miami River, are analyzed for uranium and total activity. The combined sewage is composed of treated liquid effluent from the production plants, water treatment plants waste effluent, storm sewer discharge, and treated sanitary sewage. Using the data from the combined sewage samples and stream flow data for the Great Miami River, the FMPC contribution to radioactivity concentrations in the river may be calculated. To check the calculated results, weekly upstream and downstream spot samples are taken. Table 3 presents the calculated and the spot check river concentrations. Since the calculated concentration represents only the contribution from FMPC, it should be compared with the difference of the upstream and downstream measurements. Sampling points are shown in figure 3.

TABLE 3.—CONCENTRATIONS OF URANIUM AND TOTAL ACTIVITY IN THE GREAT MIAMI RIVER, OHIO

[Average concentrations in pc/liter]

Location	Method of determination	First half 1964		
		No. of samples	Uranium [a]	Total activity [b]
Sewer outfall	Calculated from sewer concentrations and stream data (continuous sampling).	182	8	10
Upstream	Spot samples	26	7	30
Downstream	Spot samples	33	9	40
Difference		—	2	10

[a] MPC=20,000 pc/liter.
[b] MPC=3,000 pc/liter.

Recent coverage in *Radiological Health Data:*

Period	*Issue*
July–December 1960	*June 1961*
January–June 1961	*December 1961*
July 1961–June 1962	*March 1963*
July 1962–December 1963	*May 1964*

3. Knolls Atomic Power Laboratory January–June 1964

General Electric Company
Schenectady, New York

The principal function of the Knolls Atomic Power Laboratory (KAPL), operated by the General Electric Company for the Atomic Energy Commission, is to support the Naval Reactors Program of the Commission in the development of atomic power reactors for naval propulsion. This includes design, construction, and prototype operation of nuclear power reactors.

The Knolls Atomic Power Laboratory consists of two sites, the Knolls site and the West Milton site, located as shown in figure 4. The Knolls site occupies approximately 170 acres on which are located administrative buildings; chemistry, physics, metallurgical, engineering, and radioactive materials laboratories; critical assembly buildings; machine shops; decontamination facilities; radioactive waste storage and processing facilities; and nuclear fuel storage and assembly buildings. The West Milton site occupies approximately 4,000 acres. Its principal facilities include the Triton (S3G) and Bainbridge (D1G) prototype reactors, equipment service building, fuel service building, and waste treatment facility. Regular environmental monitoring activities are conducted to assure that environmental radiation concentrations resulting from laboratory operations are well within Atomic Energy Commission prescribed limits (*1*).

Air Monitoring

Environmental airborne radioactivity is measured at two locations on the Knolls site, four locations at the West Milton site, and at the General Electric Company Research Laboratory, approximately one mile west of the Knolls site. Airborne radioactivity is sampled continuously and analyzed on a weekly basis. The results of the airborne radioactivity analyses are given in table 4. Measurements of airborne radioactivity are made at least 48 hours after collection allowing the naturally occurring short-lived materials to decay.

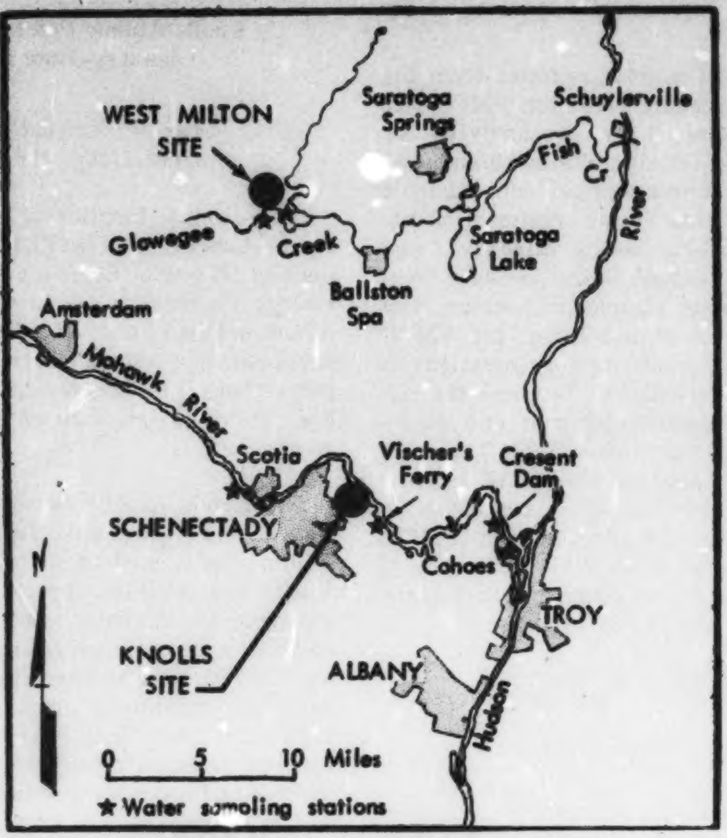
WEST MILTON SITE
Saratoga Springs
Schuylerville
Fish Cr
River
Glowegee Creek
Saratoga Lake
Ballston Spa
Amsterdam
Mohawk River
Scotia
Vischer's Ferry
Cresent Dam
SCHENECTADY
Cohoes
TROY
KNOLLS SITE
ALBANY
Hudson
N
0 5 10 Miles
★ Water sampling stations

FIGURE 4. ENVIRONMENTAL MONITORING LOCATIONS, KAPL

TABLE 4.—AIRBORNE BETA ACTIVITY, KAPL, JANUARY-JUNE 1964

[Average concentrations in pc/m³]

Sampling locations	January-June 1964
Knolls site	1.41
West Milton site	1.45
Offsite	1.38

Liquid Waste Monitoring

The dilution potential of the Mohawk River is utilized to a limited degree in the disposal of liquid radioactive wastes from the Knolls site. All potential sources of liquid radioactive waste at the Knolls site are connected by control drains to collection tanks in the radioactive waste processing building. The release of liquid waste to the Mohawk River is regulated according to (1) the concentration of fission products in the collection tanks, and (2) the flow of the river. A continuous proportional sample of the Knolls site combined sewer effluent is taken at the point of discharge to the Mohawk River. Radiochemical analyses of weekly composite samples show that strontium-90 is the principal component to be considered in control. The amounts and the radioisotopic content of the combined sewer effluent discharged from the Knolls site have been summarized in table 5. A total of 0.29 curie of beta activity was discharged to the Mohawk River during the 6-month period of this report.

TABLE 5.—RADIONUCLIDE CONCENTRATIONS IN THE KNOLLS SITE WASTE EFFLUENT, KAPL

[Average concentrations in pc/liter]

Radionuclides	January-June 1964
Sr-89	<11
Sr-90	370
Cs-137	500
Ce-144-Pr-144	200
Ru-106	<10
I-131	<11

Mohawk River water is sampled continuously at the point of discharge from the Knolls site; at the General Electric Company powerhouse eight miles upstream from the site; at the Vischer Ferry powerhouse approximately two miles downstream; and at the City of Cohoes pumping station about 13 miles downstream. Samples taken from the Cohoes station show very nearly the same average concentrations obtained for the Vischer Ferry samples (table 6).

TABLE 6.—GROSS BETA ACTIVITY IN STREAMS RECEIVING EFFLUENTS, KAPL

[Average concentration in pc/liter]

Stream and location	January–June 1964
Mohawk River (Knolls site): [a]	
G.E. Powerhouse (upstream)	10
Vischer Ferry (downstream)	11
Glowegee Creek (West Milton site): [a]	
Upstream	13
Downsteam	18

[a] MPCw = 100 pc/liter.

Since the Glowegee Creek does not have a reliable dilution potential, the radioactivity levels in the liquid waste from the West Milton site are operationally controlled and diluted prior to release to the creek. A total of 0.018 curie was discharged at two points into Glowegee Creek during the 6-month period at monthly average concentrations ranging from 7 to 80 pc/liter. Samples of the Glowegee Creek water are taken once a week at two locations, one at about 150 feet above the point where the S3G effluent enters the stream, and the other 2,640 feet below the S3G discharge or 1,500 feet below the D1G discharge.

Recent coverage in *Radiological Health Data:*

Period	Issue
Third and fourth quarters 1960	*September 1961*
First and second quarters 1961	*March 1962*
July 1961–June 1962	*July 1963*
July 1962–December 1963	*June 1964*

4. S1C Prototype Reactor Facility
January–June 1964

Combustion Engineering, Inc.
Windsor, Connecticut

The S1C Prototype is a land-based nuclear submarine power plant facility, operated for the Atomic Energy Commission by the Naval Reactors Division of Combustion Engineering, at Windsor, Connecticut. The Prototype contains a pressurized water reactor power plant which is used for research, development, and training.

All materials released to the environment are routinely monitored to assure that waste disposal operations comply with AEC regulations. Monitoring results which follow indicate that the Facility has fully complied with the standards previously described (*1*).

Essentially all of the radioactive wastes originate from activation of minute amounts of impurities and corrosion products in the circulating water used as a reactor coolant. Ventilation air from the submarine hull and the supporting facility is continuously monitored at the exhaust stack. Liquid wastes are monitored before discharge to the Farmington River. Tables 7 and 8 give the average beta concentrations of airborne and liquid wastes before release to the environment.

TABLE 7.—AIRBORNE BETA ACTIVITY, S1C, JANUARY–JUNE 1964

[Average concentrations in pc/m³]

Sampling locations	Jan.–Mar. 1964	Apr.–June 1964
Stack discharge	48	48
Onsite average	1.2	1.1
Offsite average	8.2	1.1

TABLE 8.—RADIOACTIVITY IN LIQUID WASTES DISCHARGED INTO THE FARMINGTON RIVER, S1C, JANUARY–JUNE 1964

Activity	January–June 1964
Total beta activity (millicuries)	10.35
Average gross beta concentrations (pc/liter):	
Co^{60}	1,700
Fe^{59}	100
Mn^{54}-Co^{58}	240

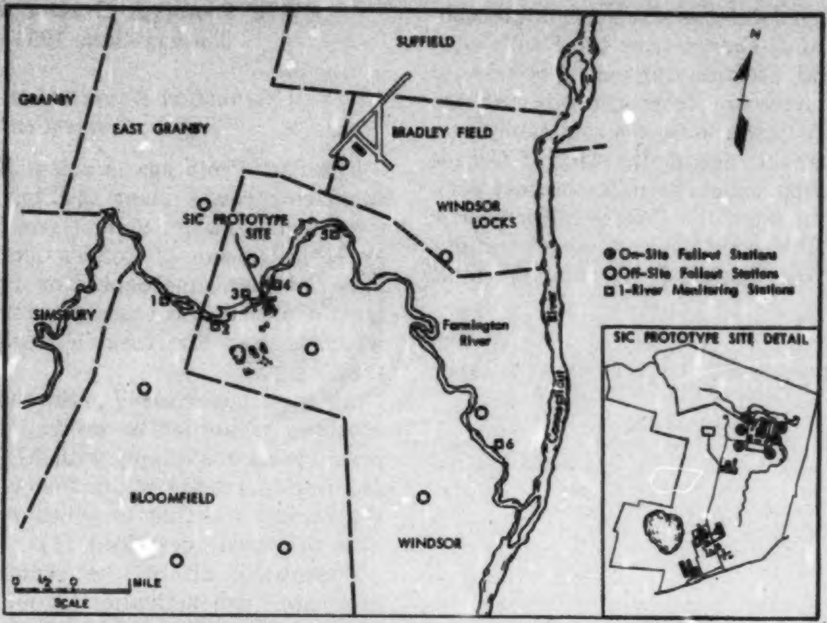
SUFFIELD
GRANBY
EAST GRANBY
BRADLEY FIELD
S1C PROTOTYPE SITE
WINDSOR LOCKS
SIMSBURY
Farmington River
Connecticut River
BLOOMFIELD
WINDSOR
N
On-Site Fallout Stations
Off-Site Fallout Stations
1-River Monitoring Stations
S1C PROTOTYPE SITE DETAIL
1
2
3
4
5
6
0 ½ 0 1 MILE
SCALE

FIGURE 5. ENVIRONMENTAL MONITORING LOCATIONS, S1C PROTOTYPE SITE

Figure 5 shows the locations of 6 water sampling stations along the Farmington River and of 17 fallout monitoring stations. A more detailed description of S1C Prototype Reactor Facility and its control measures is available in the September 1961 issue of Radiological Health Data. Comparisons of the data for upstream and downstream samples appear in table 9.

Recent coverage in *Radiological Health Data:*

Period	*Issue*
July–December 1960	*September 1960*
January–July 1961	*March 1962*
July 1961–June 1962	*July 1963*
July 1963–December 1963	*June 1964*

TABLE 9.—BETA ACTIVITY IN THE FARMINGTON RIVER, JANUARY-JUNE 1964

Sampling station (figure 5)	Activity
Water (pc/liter)	
Upstream	[a] 18.1
Outlet	[a] 18.1
Downstream	[a] 18.1
Mud (pc/g)	
Upstream	26
Outlet	[a] 10
Downstream	[a] 10

[a] Equal to background.

REFERENCES

(1) U.S. ATOMIC ENERGY COMMISSION. Rules and regulations, standards for protection against radiation, Title 10, Part 20, Appendix B, Table 2. U.S. Government Printing Office, Washington, D.C.

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REPORTED NUCLEAR DETONATIONS, MARCH 1965

During the month of March two United States nuclear tests were announced by the Atomic Energy Commission. Both tests were of low-intermediate yield (20–200 kilotons) and were conducted underground at the Nevada Test Site.

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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service • Division of Radiological Health

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Synopses of contributed articles are presented below in reference card format for the reader's convenience.

STRONTIUM-90 IN UNITED STATES WHEAT. *Pfeifer, V. F., and R. A. Anderson* (Agricultural Research Service, U. S. Department of Agriculture). *Radiological Health Data, Vol. 6, May .1965*, pp. 265–266.

As part of continuing studies intended to uncover processing methods capable of reducing strontium-90 in wheat and milling products, 77 wheat samples from 31 U.S. locations were collected and analyzed. Strontium-90 content in these samples ranged from 26 to 380 pc/kg (dry basis). Projected values for the entire U.S. wheat crop indicated an "as is" strontium-90 content of 130 pc/kg, which compares well with the Federal Radiation Council's prediction of 140 pc/kg.

THE DENTAL SURPAK PROGRAM AND RESULTS THROUGH DECEMBER 1963. *Miller, J. W.* (Division of Radiological Health) *Radiological Health Data, Vol. 6, May 1965*, pp. 271–277.

A mail-order survey for checking on dental X-ray machines for radiation exposure, the Dental Surpak program distributed 58,000 Surpaks to 39 States, as of June 30, 1964. Completed surveys of 40,000 units in 27 States indicated that 60 to 80 percent of the machines did not meet recommended standards for filtration when first inspected, but followup in 1962 and 1963 showed about 80 percent compliance of machines that were originally below standards.

STATUS OF STATE RADIUM AND BYPRODUCT MATERIAL PROGRAMS AS OF JUNE 30, 1964. *Bailey, J. G.* (Division of Radiological Health). *Radiological Health Data, Vol. 6, May 1965*, pp. 280–283.

State agencies are increasing emphasis on control and inspection of radioactive materials, with 26 States now having comprehensive programs for the control of radium. An additional 12 States identify radium users by means of licensing or registration programs. A total of 30 State programs include inspection of radium installations.

Section I—Air and Fallout

FISSION PRODUCT BETA ACTIVITY IN AIRBORNE PARTICULATES AND PRECIPITATION

Continuous surveillance of gross beta activity in air and precipitation provides one of the earliest and most sensitive indications of changes in environmental fission product activity. Although this surveillance does not provide enough information to assess human radiation exposure from fallout, it is used as an alerting system for determining when to intensify monitoring in other phases of the environment.

Surveillance data from a number of national programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. Data provided by programs of the Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization are presented individually in tabular form.

1. Radiation Surveillance Network
January 1965

Division of Radiological Health,
Public Health Service

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Surveillance Network (RSN) of the PHS Division of Radiological Health, which regularly gathers samples from 75 stations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

Alerting function

The alerting function of the network is provided by field estimates of the gross beta activity of airborne particulates on the filters. These determinations are performed about 5 hours after the end of the sampling period to allow for decay of naturally-occurring radon daughters. The network station operators telephone any daily field estimates over 10 pc/m^3 to the Radiation Surveillance Center, Division of Radiological Health, Washington, D.C. Lower field estimates are reported to the Center by the laboratory at Rockville, Maryland, which receives a daily written report together with the air filter submitted by each station operator. The filters are counted at the laboratory to confirm field estimates. Analyses for specific radionuclides may also be made if gross beta activity concentrations are high. All field estimates are reported elsewhere on a monthly basis (*1*). When unusually high air levels are reported, appropriate Federal and State officials are promptly notified.

Air sampling procedure and results

Airborne particulates are collected continuously on carbon-loaded cellulose dust filters 4 inches in diameter. A volume of about 1,800 cubic meters of air is drawn through each filter during the 24-hour sampling period by a high volume centrifugal blower.

The filters are forwarded to the Radiation Surveillance Network laboratory in Rockville, Maryland, where the gross beta activity is measured using a thin-window, gas-flow proportional counter, calibrated with a Sr^{90}–Y^{90} standard. Each filter is counted 4 days after the end of the sampling period and again 7 days later if the net count rate is 3,000 cpm or higher. The initial 4-day aging of the sample eliminates interference from naturally-occurring radon and thoron daughters. By using the two counts and the Way-Wigner formula (*2*), the age of fission products is estimated, and the activity extrapolated to the time of

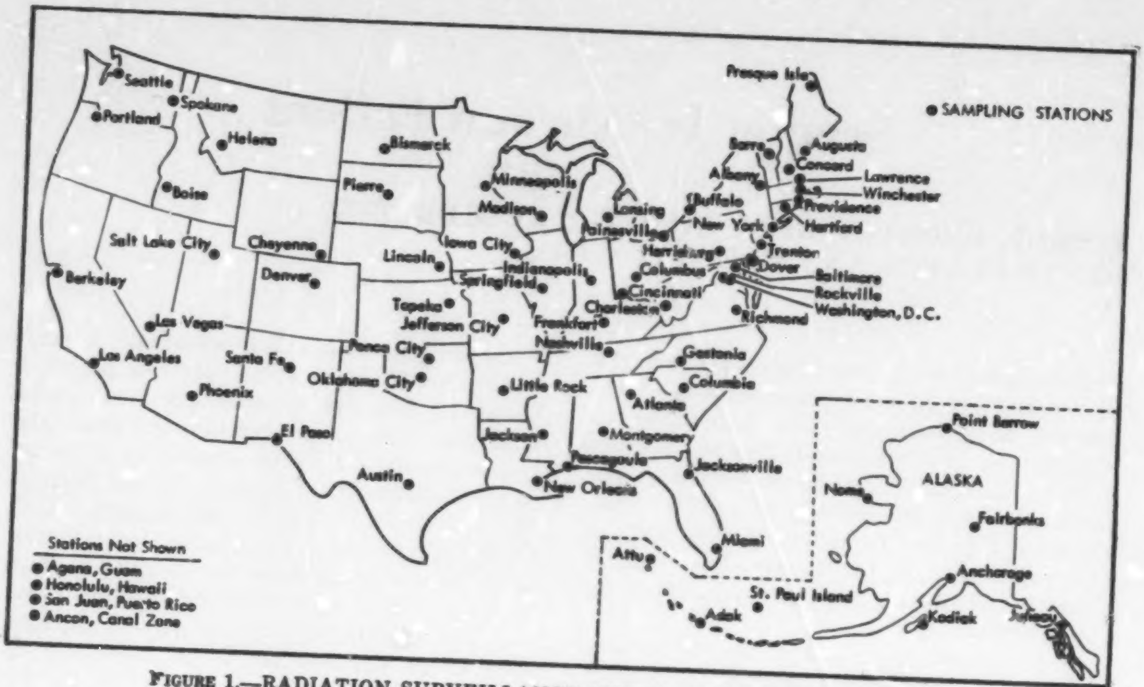
SAMPLING STATIONS
Seattle
Spokane
Portland
Helena
Boise
Bismarck
Pierre
Minneapolis
Madison
Salt Lake City
Cheyenne
Lincoln
Iowa City
Berkeley
Denver
Indianapolis
Springfield
Topeka
Jefferson City
Las Vegas
Los Angeles
Santa Fe
Ponca City
Oklahoma City
Phoenix
El Paso
Austin
Little Rock
Jackson
Montgomery
Pascagoula
New Orleans
Jacksonville
Miami
Presque Isle
Barre
Augusta
Concord
Albany
Lawrence
Winchester
Buffalo
Providence
Lansing
Painesville
New York
Hartford
Trenton
Harrisburg
Columbus
Dover
Baltimore
Cincinnati
Rockville
Charleston
Washington, D.C.
Frankfort
Richmond
Nashville
Gastonia
Columbia
Atlanta
Point Barrow
ALASKA
Nome
Fairbanks
Attu
Anchorage
St. Paul Island
Adak
Kodiak
Juneau
Stations Not Shown
● Agana, Guam
● Honolulu, Hawaii
● San Juan, Puerto Rico
● Ancon, Canal Zone

FIGURE 1.—RADIATION SURVEILLANCE NETWORK SAMPLING STATIONS

collection.[1] The daily concentrations and estimated ages of selected samples are reported by the PHS in a monthly RSN report (*1*).

The January 1965 air sampling results are given in table 1. Time profiles of gross beta activity in air for eight RSN stations are shown in figure 2.

During January 1965, 125 air samples were analyzed by gamma spectroscopy. The method discussed by Burrus (*3*) and Covell (*4*) was adapted for resolving the complex gamma scan data. Only two air samples and no precipitation samples were found to contain identifiable short-lived radionuclides. Tellurium-iodine-132 was present in Los Angeles samples for January 13 and 14 at concentrations of approximately 1.5 pc/m^3; I^{131}, Np^{239}, Ba-La^{140}, Zr-Nb^{95}, Ru-Rh^{103,106} were identified at concentrations below 1 pc/m^3.

Precipitation measurements

Continuous sampling for radioactivity in precipitation is conducted at most stations on a daily basis, using funnels with collection areas of 0.4 square meter. A 500-ml portion of the collected precipitation is evaporated to dryness, and the residue is forwarded to the laboratory for analysis. If the collected sample is between 200 and 500 ml, the entire sample is evaporated. When a sample is smaller than 200 ml (equivalent to 0.5 mm or 0.02 inches of rainfall), the volume of precipitation is reported, but no analysis is made.

In the laboratory the gross beta activity in precipitation is determined by counting the evaporated sample by the same method used for analyzing the air filters, including the extrapolation to time of collection. Deposition for the sample is determined by: $D = CP/1000$, where D is the deposition in nc/m^2, C is the concentration in pc/liter, and P is the depth of precipitation in mm. The individual values of deposition and depth of precipitation are totaled for the month, and the average concentration for the month, $\overline{C}$, is determined by:

$$\overline{C} = \frac{\Sigma D}{\Sigma P} \times 1000$$

The January 1965 precipitation measurements are given in table 1.

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[1] If a sample contains a mixture of fresh and old fission products, the age estimated by the Way-Wigner formula is of some intermediate value; consequently the calculated age of the fresh component will be overestimated.

TABLE 1.—GROSS BETA ACTIVITY IN SURFACE AIR AND PRECIPITATION, JANUARY 1965

Station location		Air surveillance					Precipitation measurements	
		Number of samples	Gross beta activity, pc/m^3			Last profile in *RHD*	Total depth (mm)	Total deposition (nc/m^2) [b]
			Maximum	Minimum	Average [a]			
Ala:	Montgomery	31	0.35	<0.10	<0.22	May 65	162.7	32.5
Alaska:	Adak	24	0.28	<0.10	<0.15	Nov 64	[b]	[b]
	Anchorage	30	0.46	<0.10	0.22	May 65	12.2	2.4
	Attu Island	17	0.29	<0.10	<0.14	Dec 64		
	Fairbanks	19	0.20	<0.10	<0.13	Aug 64	7.1	1.4
	Juneau	13	0.24	<0.10	<0.13	Sep 64	2.2	0.5
	Kodiak	16	0.81	<0.10	<0.29	Oct 64		
	Nome	14	0.25	<0.10	<0.15	Feb 65		
	Point Barrow	27	0.27	<0.10	0.13	Jan 65		
	St. Paul Island	28	0.44	<0.10	<0.20	Mar 65		
Ariz:	Phoenix	22	1.00	0.11	0.37	Sep 64		
Ark:	Little Rock	25	0.41	0.11	0.22	Sep 64	116.4	23.3
Calif:	Berkeley	29	0.38	<0.10	<0.13	Oct 64	98.0	19.4
	Los Angeles	27	1.81	<0.10	0.39	Feb 65	19.2	3.8
Canal Zone:	Ancon	15	0.30	<0.10	<0.14	Nov 64		
Colo:	Denver	23	0.50	<0.10	0.26	Oct 64	7.2	1.5
Conn:	Hartford	26	0.38	<0.10	0.21	Oct 64	29.9	7.7
Del:	Dover	17	0.46	0.15	0.27	May 65		
D. C:	Washington	27	0.52	<0.10	0.28	Feb 65	55.3	12.7
Fla:	Jacksonville	27	0.44	<0.10	0.27	Sep 64	10.5	2.3
	Miami	30	0.65	0.11	0.30	Oct 64	38.8	8.0
Ga:	Atlanta	9	0.32	<0.10	0.20	Apr 65		
Guam:	Agana	30	0.81	<0.10	0.34	Apr 65		
Hawaii:	Honolulu	30	0.57	<0.10	0.22	Dec 64	38.4	8.4
Idaho:	Boise	24	0.61	<0.10	<0.19	Dec 64	74.3	15.8
Ill:	Springfield	31	0.34	<0.10	0.20	Feb 65		
Ind:	Indianapolis	27	0.37	0.13	0.22	Apr 65	88.4	18.2
Iowa:	Iowa City	28	0.51	<0.10	0.25	Nov 64	51.0	10.5
Kans:	Topeka	25	0.38	<0.10	0.20	May 65	41.6	8.4
Ky:	Frankfort	23	0.42	<0.10	0.28	Feb 65	48.0	10.7
La:	New Orleans	27	0.42	<0.10	0.21	Feb 65	33.5	6.7
Maine:	Augusta	30	0.40	0.12	0.26	Mar 65	45.0	9.3
	Presque Isle	19	0.32	<0.10	0.20	Nov 64		
Md:	Baltimore	20	0.33	<0.10	0.22	Oct 64	10.0	2.0
	Rockville	15	0.42	<0.10	0.24	Jan 65		
Mass:	Lawrence	31	0.51	<0.10	0.28	May 65	15.1	3.8
	Winchester	28	0.64	0.20	0.36	Dec 64	64.4	65.8
Mich:	Lansing	31	0.42	<0.10	0.23	Jan 65		
Minn:	Minneapolis	21	0.37	<0.10	0.16	Apr 65	7.0	1.7
Miss:	Jackson	28	0.58	<0.10	0.23	Mar 65	69.7	13.9
	Pascagoula	12	0.40	<0.10	0.27	Dec 64		
Mo:	Jefferson City	29	0.31	<0.10	0.18	Apr 65	87.0	19.2
Mont:	Helena	30	0.54	<0.10	<0.19	Nov 64	6.39	1.40
Nebr:	Lincoln	14	0.60	<0.10	0.26	Mar 65		
Nev:	Las Vegas	28	0.69	<0.10	0.27	Aug 65		
N. H:	Concord	20	0.52	0.17	0.33	Feb 65		
N. J:	Trenton	31	0.53	<0.10	0.26	Mar 65	14.8	3.2
N. Mex:	Santa Fe	27	0.56	<0.10	0.23	Nov 64	30.9	6.1
N. Y:	Albany	21	0.68	0.14	0.26	Apr 64	34.5	6.9
	Buffalo	23	0.55	0.16	0.28	Nov 64		
	New York	22	0.56	0.16	0.30	Dec 64		
N. C:	Gastonia	27	0.63	<0.10	0.31	Nov 64	54.4	10.9
N. Dak:	Bismarck	28	0.32	<0.10	0.17	Jan 65	18.6	3.7
Ohio:	Cincinnati	21	0.37	0.11	0.20	May 65		
	Columbus	29	0.75	<0.10	0.33	Mar 65	51.5	12.7
	Painesville	30	0.60	<0.10	0.33	Oct 64	96.8	22.1
Okla:	Oklahoma City	28	0.41	<0.10	0.18	Jan 65		
	Ponca City	28	0.28	<0.10	<0.13	Oct 64	47.6	9.9
Ore:	Portland	27	0.69	<0.10	<0.21	Mar 65	122.0	28.4
Pa:	Harrisburg	29	0.49	<0.10	0.22	Apr 65	29.4	5.9
P. R:	San Juan	29	0.49	<0.10	<0.18	Mar 65	36.2	7.2
R. I:	Providence	27	0.52	0.12	0.27	Jan 65	11.4	2.6
S. C:	Columbia	27	0.72	<0.10	0.26	Dec 64	38.6	10.0
S. Dak:	Pierre	31	0.33	0.13	0.19	Sep 64		
Tenn:	Nashville	29	0.58	<0.10	0.28	Jan 65	73.4	16.0
Tex:	Austin	28	0.46	0.11	0.28	May 65	73.6	14.9
	El Paso	27	1.37	<0.10	0.46	Jan 65	5.6	1.5
Utah:	Salt Lake City	27	0.84	<0.10	0.28	Feb 65	56.5	11.8
Vt:	Barre	29	0.65	0.19	0.34	Sep 64	18.0	5.6
Va:	Richmond	31	0.34	<0.10	0.20	Sep 64	39.1	8.5
Wash:	Seattle	30	0.26	<0.10	<0.12	May 65	102.8	20.6
	Spokane	31	0.40	<0.10	<0.16	Apr 65		
W. Va:	Charleston	30	0.57	<0.10	0.29	Dec 64	89.4	18.5
Wis:	Madison	30	0.64	<0.10	0.27	Sep 64	19.5	3.9
Wyo:	Cheyenne	30	1.04	<0.10	0.35	Aug 64	6.5	2.3
Network summary [c]		1,904	1.81	<0.10	<0.24		46.2	10.9

[a] The monthly average is calculated by weighting the individual samples with the length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If the <0.10 values represent more than 10 percent of the average, a less-than sign is placed before the average.

[b] Blank indicates no report received.

[c] For the network summary, all averages are arithmetic means of station averages.

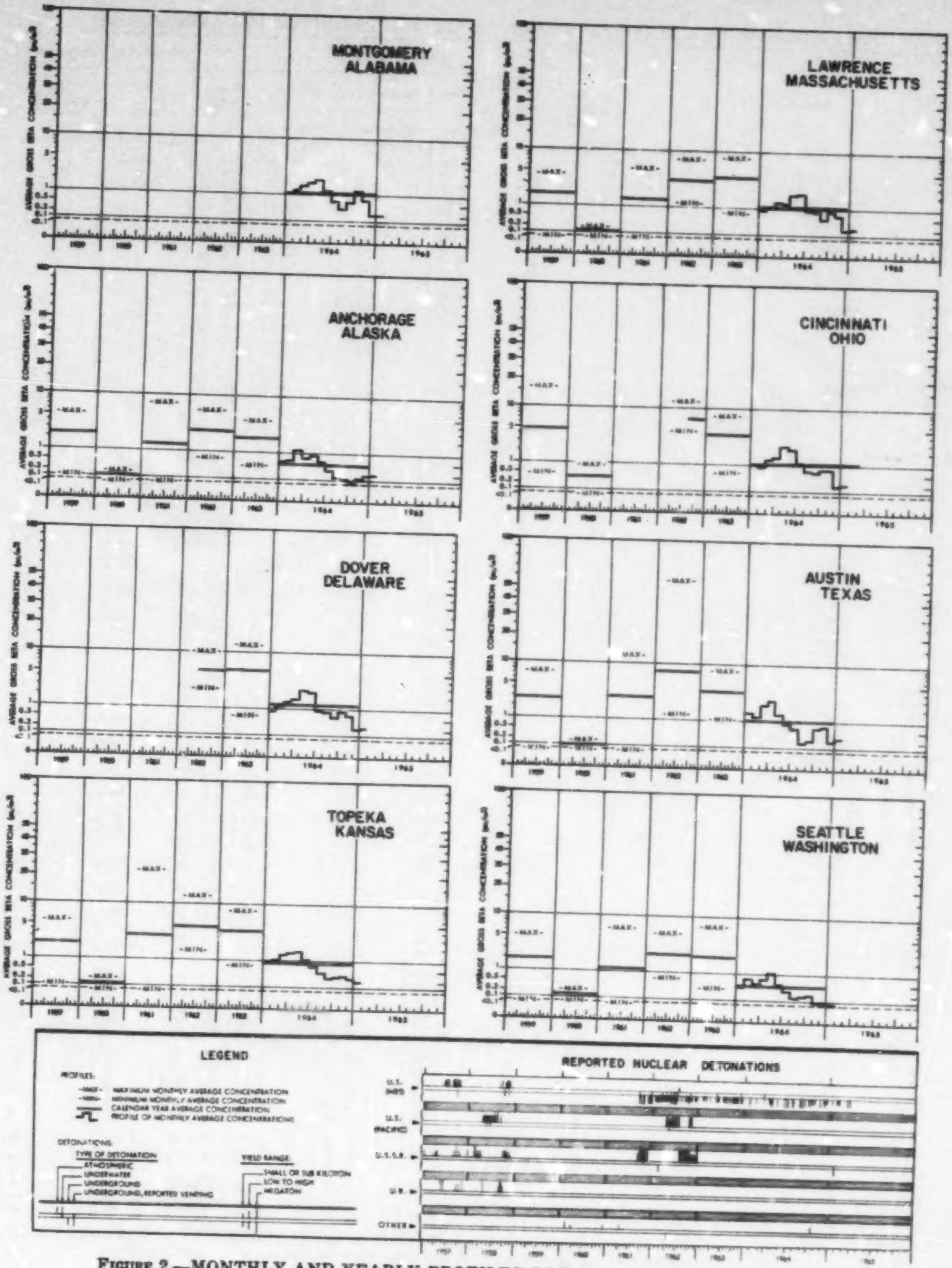

FIGURE 2.—MONTHLY AND YEARLY PROFILES OF BETA ACTIVITY IN AIR—RADIATION SURVEILLANCE NETWORK, 1959—JANUARY 1965

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2. Canadian Air Monitoring Program[2] January 1965

Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (see figure 3), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*5–9*).

Air

Each air sample involves the collection of particulates from about 650 cubic meters of air drawn through a high-efficiency 4-inch-diameter glass-fiber filter during a 24-hour period. These filters are sent daily to the Radiation Protection Division Laboratory in Ottawa. At the laboratory, a 2-inch-diameter disk is cut from each filter and counted with a thin-end window, gas-flow, Geiger-Mueller counter system calibrated with a Sr^{90}–Y^{90} standard. Four successive measurements are made on each filter to permit correction for natural activities and for the decay of short-lived fission products. The results are extrapolated to the end of the sampling period. Canadian air data for January 1965 are given in table 2.

Precipitation

The amount of radioactive fallout deposited on the ground is determined from measurements on material collected in special polyethylene-lined rainfall pots. The collection period for each sample is one month. After transfer of the water to the sample container, the polyethylene liner is removed, packed with the sample, and sent to the laboratory.

Strontium and cesium carriers are added to all samples on arrival at the laboratory. Other carriers are also added to selected samples according to the specific radionuclides to be determined. The samples are then filtered and the filtrate evaporated to near dryness. The filter paper containing insoluble matter is ignited together with the polyethylene liner at 450 degrees C. The ash is combined with the soluble fraction, transferred to a glass planchet, evaporated under an infra-red lamp, and then counted with a thin-end-window Geiger-Mueller counter calibrated with a Sr^{90}–Y^{90} source. Gross beta activities for January 1965 samples are given in table 2. Radionuclide analyses are reported quarterly in *RHD*.

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[2] Data from RADIATION PROTECTION DIVISION. *Radiation Protection Programs*, Vol. 3, No. 2: 16–24 (February 1965), Canadian Department of National Health and Welfare, Ottawa, Canada.

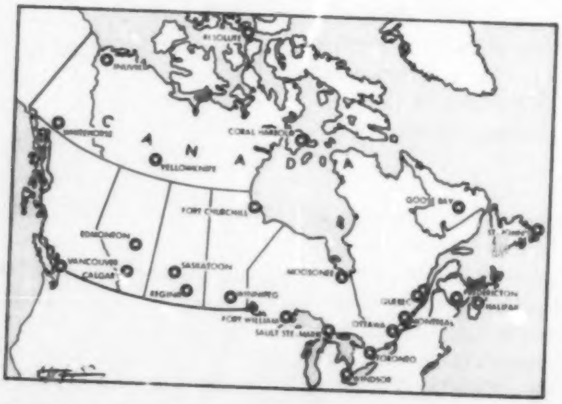

FIGURE 3.—CANADIAN AIR AND PRECIPITATION SAMPLING STATIONS

TABLE 2.—GROSS BETA ACTIVITY IN SURFACE AIR AND PRECIPITATION, CANADA, JANUARY 1965

Station location	Air surveillance				Precipitation measurements	
	Number of samples	Gross beta activity (pc/m³)			Average concentration (pc/liter)	Total deposition (nc/m²)
		Maximum	Minimum	Average		
Calgary	31	0.3	0.0	0.2	207	1.9
Coral Harbour	31	0.3	0.0	0.2	241	2.4
Edmonton	31	0.2	0.0	0.2	52	2.6
Ft. Churchill	31	0.3	0.0	0.2	86	1.5
Ft. William	29	0.5	0.0	0.3	90	1.9
Fredericton	31	0.2	0.0	0.1	55	3.4
Goose Bay	31	0.3	0.1	0.2	410	3.4
Halifax	31	0.3	0.1	0.2	131	13.5
Inuvik	31	0.4	0.1	0.2	66	1.1
Montreal	31	0.4	0.1	0.3	92	5.1
Moosonee	31	0.3	0.1	0.2	41	2.1
Ottawa	30	0.5	0.1	0.2	50	2.7
Quebec	31	0.3	0.2	0.2	65	6.2
Regina	31	0.6	0.0	0.2	106	0.9
Resolute	31	0.3	0.0	0.2	trace	2.5
St. John's, Nfld	29	0.3	0.0	0.1	35	4.2
Saskatoon	15	0.3	0.0	0.2	122	1.1
Sault Ste. Marie	31	0.4	0.0	0.2	38	4.2
Toronto	31	0.3	0.0	0.2	105	9.8
Vancouver	31	0.2	0.0	0.1	56	10.7
Whitehorse	31	0.3	0.0	0.2	62	1.0
Windsor	31	0.4	0.0	0.2	83	9.6
Winnipeg	31	0.4	0.1	0.2	305	1.7
Yellowknife	31	0.3	0.1	0.2	121	0.9
Network summary	704	0.3	0.0	0.2	114	3.9

3. Mexican Air Monitoring Program January 1965

National Commission of Nuclear Energy

The Radiation Surveillance Network of Mexico was established by the Comisión Nacional de Energía Nuclear (CNEN), Mexico City. From 1952 to 1961 the network was directed by the Institute of Physics of the University of Mexico, under contract to the CNEN (*10–14*).

In 1961 the CNEN appointed its Division of Radiological Protection to establish a new Radiation Surveillance network. This network consists of 17 stations (see figure 4), twelve of which are located at airports and operated by airline personnel. The remaining five stations are located at Mexico City, Mérida, Veracruz, San Luis Potosí, and Ensenada. Staff members of the DRP operate the station at Mexico City, while the other four stations are manned by members of the Centro de Previsión del Golfo de México, the Chemistry Department of the

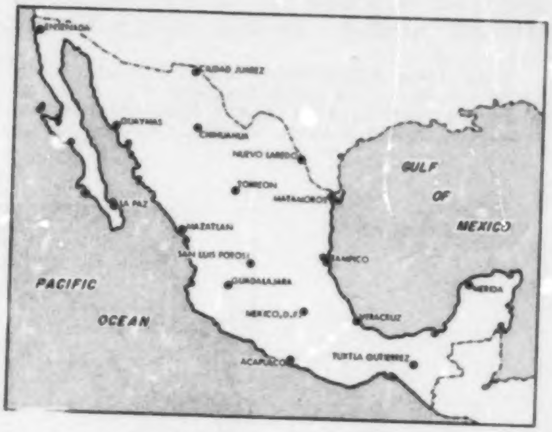
ENSENADA
CIUDAD JUAREZ
GUAYMAS
CHIHUAHUA
NUEVO LAREDO
TORREON
MATAMOROS
LA PAZ
MAZATLAN
SAN LUIS POTOSI
GUADALAJARA
TAMPICO
MERIDA
MEXICO, D.F.
VERACRUZ
ACAPULCO
TUXTLA GUTIERREZ
GULF OF MEXICO
PACIFIC OCEAN

FIGURE 4.—FALLOUT NETWORK SAMPLING STATIONS IN MEXICO

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University of Mérida, the Institute de Zonas Desérticas of the University of San Luis Potosí, and the Escuela Superior de Ciencias Marinas of the University of Baja California, respectively.

Sampling

The sampling procedure involves drawing air for 24 hours a day, 3 or 4 days a week at the rate of approximately 1,200 cubic meters per day, through a high-efficiency, 6 x 8-inch glass fiber filter, using high volume samplers. After each 24-hour sampling period, the filter is removed and forwarded via air mail to the "Laboratorio de Estudios sobre Contaminación Radiactiva," CNEN, in Mexico City for assay of gross beta activity. A minimum of 3 or 4 days after collection is allowed for decay of radon and thoron daughter natural radioactivity. Data are not extrapolated to time of collection.

Results

The maximum, minimum, and average fission product beta concentrations in surface air during January 1965 are presented in table 3.

TABLE 3.—GROSS BETA ACTIVITY OF AIRBORNE PARTICULATES, MEXICO, JANUARY 1965

Station	Number of samples	Gross beta activity, pc/m³		
		Maximum	Minimum	Average
Acapulco	8	0.2	<0.1	0.1
Ciudad Juárez	18	0.5	<0.1	0.2
Chihuahua	12	0.4	<0.1	0.2
Ensenada	11	0.3	<0.1	0.2
Guadalajara	9	0.2	<0.1	0.1
Guaymas	11	0.4	<0.1	0.1
La Paz	18	0.6	0.1	0.3
Matamoros	6	(a)	(a)	<0.1
Mazatlán	—	—	—	—
Mérida	10	0.3	<0.1	0.1
México, D.F.	12	0.1	<0.1	<0.1
Nuevo Laredo	10	(a)	(a)	<0.1
San Luis Potosí	12	0.2	<0.1	0.1
Tampico	13	0.9	0.1	0.2
Torreón	13	0.5	<0.1	0.2
Tuxtla Gutiérrez	(a)	(a)	(a)	(a)
Veracruz	5	0.3	<0.1	0.1

[a] Station temporarily shut down.

4. Pan American Air Sampling Program January 1965

Pan American Health Organization and Public Health Service

Gross beta activity in air is monitored in the Americas under the auspices of a collaborative program, developed by the Pan American Health Organization and the Public Health Service (PHS), for assisting countries of the Americas in developing radiological health programs. The sampling equipment and analytical services are provided by the Division of Radiological Health, PHS, and are identical with those employed for the Radiation Surveillance Network.

The five air sampling stations included in the Program are operated by the technical staff of the Ministry of Health in each country. The station in Kingston, Jamaica, is operated by the Public General Hospital; in Caracas, Venezuela, by the Venezuelan Institute for Scientific Investigations; in Lima, Peru, by the Institute of Occupatonal Health; in Santiago, Chile, by the Occupational Health Service. The Kingston station began operation in March 1964, and the other three were started near the end of 1962.

The January 1965 air monitoring results from the four participating countries are given in table 4.

TABLE 4.—GROSS BETA ACTIVITY IN AIR, JANUARY 1965

Sampling stations	Gross beta activity, pc/m³			
	No. of samples	Maximum	Minimum	Average [a]
Kingston, Jamaica	18	0.32	<0.10	<0.14
Caracas, Venezuela	20	0.19	<0.10	<0.10
Lima, Peru	0			
Santiago, Chile	28	0.31	<0.10	<0.14

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If the <0.10 values represent more than 10 percent of the average, a less-than sign is placed in front of the average.

5. Gross Beta Activity in Air, North America January 1965

Beginnning with January 1963 data, monthly average concentrations of airborne gross beta activity in Canada and the United States have been presented in combined form as isogram maps of most of North America. The data from the Radiation Surveillance Network and the Canadian Air Network were adjusted to each other by means of an intercalibration factor derived by Lockhart and Patterson (*15*).

With the formation of the Mexican Air Monitoring program, new intercalibration ratios were determined, this time including the Canadian Network, Radiation Surveillance Network, Pan American Air Sampling Program, National Air Sampling Network, the HASL 80th Meridian Network, and the Mexican Network (*16*). The new intercalibration factors reflect some changes in standardization in both the RSN and the Canadian Air Network, effective September 1963.

During January 1965, gross beta activity was less than 0.5 pc/m^3 at all stations; therefore, an isogram is not presented.

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Section II—Milk and Food

MILK SURVEILLANCE

Although milk is only one of the many sources of dietary intake of radionuclides, it is the single food item most often used as an indicator of the population's intake of radionuclides from the environment. This is because fresh milk is consumed by a large segment of the United States population and contains most of the radionuclides occurring in the environment which have been identified as biologically important. In addition, milk is produced and consumed on a regular basis, is convenient to handle, is easily analyzed, and samples representative of milk consumption in any area can be readily obtained.

1. Pasteurized Milk Network
January 1965

Division of Radiological Health and Division of Environmental Engineering and Food Protection, Public Health Service

The Public Health Service pasteurized milk surveillance program had its origin in a raw milk sampling network (*1*) established by the Service in 1957. One of the primary objectives of the raw milk network was the development of methods for milk collection and radiochemical analysis suitable for larger scale programs.

Experience derived from this earlier network led to the activation of a pasteurized milk sampling program with stations selected to provide nationwide surveillance of milk production and consumption areas. The present network, which consists of 63 stations, has at least one station in every State, the Canal Zone, and Puerto Rico.

Sampling procedure

Through the cooperation of State and local milk sanitation authorities, samples are routinely collected at each station. The method specifies that each station's sample be composited of subsamples from each milk processing plant in proportion to the plant's average sales in the community served. At most stations the sample represents from 80 to 100 percent of the milk processed. Prior to September 15, 1961, the composite sample was taken from one day's sales per month and was as representative of the community's supply as could be achieved under practical conditions. Beginning with the resumption of nuclear weapons testing in the atmosphere in September 1961, and continuing through January 1963, samples were collected twice a week at nearly all stations and daily for short periods at selected stations. Since then, the sampling frequency has been reduced to once a week.

Samples are preserved with formaldehyde and sent to the PHS Southwestern (SWRHL), Southeastern (SERHL), or Northeastern Radiological Health Laboratories (NERHL) for analysis. Gamma analyses for iodine-131 are made within 3 to 6 days after sample collection, and any results exceeding 100 pc/liter are immediately telephoned to State health officials for possible public health action. Analytical results are normally available 6 to 7 weeks after weekly samples are received by the laboratories; publication in *RHD* follows 3 to 4 months after the monthly samples are composited for analyses.

Analytical procedures

Iodine–131, cesium–137, and barium–140 concentrations are determined by gamma scintillation spectroscopy.[1] After the weekly samples are gamma scanned, samples from two consecutive weeks are composited and analyzed radiochemically for strontium–89 and strontium–90. There is an inherent statistical variation associated with all measurements of radionuclide concentrations. With the low radionuclide levels which are usually found in milk and other environmental samples, this variation on a percentage basis is relatively high. The variation depends upon such factors as the method of chemical analysis, the sample counting rate and counting time, interferences from other radionuclides, and the background count. For milk samples, counting times of 50 minutes for gamma spectroscopy and 30 to 50 minutes for beta determinations are used. Table 1 shows the approximate total analytical error (including counting error) associated with radionuclide concentrations in milk. These errors were determined by comparing results of a large number of replicate analyses.

The minimum detectable concentration is defined as the measured concentration at which the two-standard-deviation analytical error is equal to the measurement. Accordingly, the minimum detectable concentrations in units of pc/liter are Sr^{89}, 5; Sr^{90}, 2; Cs^{137}, 10; Ba^{140}, 10; and I^{131}, 10. At these levels and below, the counting error comprises nearly all of the analytical error.

Calcium analyses at SERHL are done by an ion exchange and permanganate titration method, while at NERHL and SWRHL an ethylenediaminetetraacetic acid (EDTA) method is used. Stable potassium concentrations are estimated from the potassium–40 concentrations[2] determined from the gamma spectrum.

Data presentation

TABLE 1.—ANALYTICAL ERRORS ASSOCIATED WITH ESTIMATED CONCENTRATIONS FOR SELECTED RADIONUCLIDES IN MILK

Nuclide	Estimated concentration (pc/liter)	Error [a] (pc/liter)	Estimated concentration (pc/liter)	Error [a] (percent of concentration)
Iodine-131	0 to 100	±10	100 or greater	±10
Barium-140	0 to 100	±10	100 or greater	±10
Cesium-137	0 to 100	±10	100 or greater	±10
Strontium-89	0 to 50	± 5	50 or greater	±10
Strontium-90	0 to 20	± 2	20 or greater	±10

[a] Two standard deviations (2σ).

Table 2 presents summaries of the analyses for the preceding quarter and January 1965 (actual reporting period is December 27, 1964—January 30, 1965). The radionuclide values reported by a laboratory as being below the minimum detectable concentration have been averaged by using one-half the minimum detectable value. The averaging procedure was modified for iodine–131 and barium–140 in October 1963 when nondetectable concentrations of these radionuclides were considered zero. A similar procedure is used for the network average.

Figures 1 and 2 are isogram maps showing the estimated strontium–90 and cesium–137 concentrations in milk over the entire country. The value printed beside each station is the monthly average concentration for that station. The isograms were developed by arbitrary interpolation between values for the individual stations. Additional modifications to the isograms are made according to available information on milksheds.

In tables 3 and 4, the distribution of the network's stations *versus* radionuclide concentrations in milk for the last 6 months are compared.

The average monthly strontium–90 concentrations in pasteurized milk from selected cities in the sampling program are presented in figure 3. Each graph shows the strontium–90 concentrations in milk from one city in U.S. Bureau of Census regions. This method of selection permits graphic presentation of data for each city in the network three times a year.

For special purposes of comparison and reference, the Network maximum, minimum, and average monthly radionuclide concentrations for the early years of operation (March 1960—March 1964) were summarized in tabular form in the July 1964 *RHD* (*2*). An annual summary for 1964 appeared in the April 1965 *RHD* (*3*).

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[1] Southeastern Radiological Health Laboratory employs a radiochemical procedure for barium–140 analysis.

[2] The conversion factor is 1.18×10^{-3} g K/pc K^{40}.

TABLE 2.—AVERAGE CONCENTRATION OF STABLE ELEMENTS AND RADIONUCLIDES [a] IN PASTEURIZED MILK, FOURTH QUARTER 1964 AND JANUARY 1965

Sampling locations		Calcium (g/liter)		Strontium-89 (pc/liter)		Strontium-90 (pc/liter)		Cesium-137 (pc/liter)		Iodine-131 (pc/liter)	
		Fourth quarter	Avg. for month	Fourth quarter	Avg. for month	Fourth quarter	Avg. for month	Fourth quarter	Avg. for month	Fourth quarter	Avg. for month
Ala:	Montgomery	1.20	1.18	<5	<5	19	20	60	55	0	0
Alaska:	Palmer	1.22	1.14	<5	<5	19	15	80	65	0	0
Ariz:	Phoenix	1.19	1.17	<5	<5	4	3	25	25	0	0
Ark:	Little Rock	1.17	1.18	<5	<5	32	33	60	70	0	0
Calif:	Sacramento	1.26	1.23	<5	<5	5	5	25	35	0	0
	San Francisco	1.22	1.21	<5	<5	8	8	30	35	0	0
C. Z:	Cristobal	1.14	1.16	<5	<5	5	6	50	45	0	0
Colo:	Denver	1.29	1.29	<5	<5	16	17	65	55	0	0
Conn:	Hartford	1.13	1.10	<5	<5	14	16	85	90	0	0
Del:	Wilmington	1.17	1.15	<5	<5	16	18	70	80	0	0
D. C:	Washington	1.15	1.15	<5	<5	17	19	45	55	0	0
Fla:	Tampa	1.18	1.18	<5	<5	15	13	210	175	0	0
Ga:	Atlanta	1.20	1.21	<5	<5	24	26	85	85	0	0
Hawaii:	Honolulu	1.20	1.15	5	<5	13	11	70	70	0	0
Idaho:	Idaho Falls	1.23	1.22	<5	<5	19	18	80	110	0	0
Ill:	Chicago	1.16	1.12	<5	<5	16	16	75	85	0	0
Ind:	Indianapolis	1.20	1.20	<5	<5	15	16	60	70	0	0
Iowa:	Des Moines	1.22	1.13	<5	<5	21	21	55	50	0	0
Kans:	Wichita	1.26	1.27	<5	<5	17	16	40	45	0	0
Ky:	Louisville	1.18	1.18	<5	5	23	21	45	60	0	0
La:	New Orleans	1.23	1.23	10	<5	40	40	75	75	0	0
Maine:	Portland	1.18	1.14	<5	<5	24	22	145	140	0	0
Md:	Baltimore	1.16	1.18	<5	<5	18	17	50	60	0	0
Mass:	Boston	1.15	1.13	<5	<5	22	22	125	140	0	0
Mich:	Detroit	1.17	1.13	<5	<5	15	15	75	85	10	0
	Grand Rapids	1.20	1.17	<5	<5	19	17	85	90	0	0
Minn:	Minneapolis	1.24	1.19	5	<5	24	23	80	85	0	0
Miss:	Jackson	1.23	1.26	<5	<5	32	33	60	55	0	0
Mo:	Kansas City	1.22	1.21	<5	<5	21	22	40	55	0	0
	St. Louis	1.24	1.23	<5	<5	18	16	45	50	0	0
Mont:	Helena	[illegible]	1.19	<5	<5	16	17	85	90	0	0
Nebr:	Omaha	1.19	1.20	<5	<5	17	15	45	45	0	0
Nev:	Las Vegas	1.24	1.20	<5	<5	8	8	50	40	0	0
N. H:	Manchester	1.18	1.17	<5	<5	23	24	155	165	0	0
N. J:	Trenton	1.12	1.12	<5	<5	15	14	70	80	0	0
N. Mex:	Albuquerque	1.23	1.21	<5	<5	9	12	45	45	0	0
N. Y:	Buffalo	1.11	1.12	<5	<5	16	16	90	105	0	0
	New York	1.15	1.11	<5	<5	19	16	95	105	0	0
	Syracuse	1.12	1.09	<5	<5	15	16	90	95	0	0
N. C:	Charlotte	1.21	1.22	<5	<5	33	30	65	65	0	0
N. Dak:	Minot	1.19	1.18	<5	<5	38	54	110	130	0	0
Ohio:	Cincinnati	1.19	1.17	<5	<5	17	17	60	70	0	0
	Cleveland	1.17	1.16	<5	<5	18	17	75	90	0	0
Okla:	Oklahoma City	1.18	1.19	5	5	18	15	45	50	0	0
Ore:	Portland	1.29	1.29	<5	<5	22	15	90	80	0	0
Pa:	Philadelphia	1.18	1.15	<5	<5	16	16	65	70	0	0
	Pittsburgh	1.18	1.15	<5	<5	24	24	85	105	0	0
P. R:	San Juan	1.14	1.15	<5	<5	10	12	50	55	0	0
R. I:	Providence	1.17	1.16	<5	<5	18	20	95	105	0	0
S. C:	Charleston	1.17	1.19	<5	<5	29	28	90	85	0	0
S. Dak:	Rapid City	1.03	1.08	<5	<5	27	27	115	125	0	0
Tenn:	Chattanooga	1.20	[illegible].24	5	<5	31	32	65	70	0	0
	Memphis	1.20	1.19	<5	<5	25	26	45	45	0	0
Tex:	Austin	1.14	1.15	<5	<5	7	8	25	30	0	0
	Dallas	1.18	1.18	<5	<5	15	19	35	45	0	0
Utah:	Salt Lake City	1.34	1.27	<5	<5	18	21	90	125	0	0
Vt:	Burlington	1.16	1.10	<5	<5	20	21	105	120	10	0
Va:	Norfolk	1.19	1.18	<5	<5	21	23	60	60	0	0
Wash:	Seattle	1.24	1.24	<5	<5	20	21	95	85	0	0
	Spokane	1.30	1.28	<5	<5	22	23	95	110	0	0
W. Va:	Charleston	1.16	1.17	<5	<5	17	15	40	50	0	0
Wis:	Milwaukee	1.22	1.18	<5	<5	14	14	85	95	0	0
Wyo:	Laramie	1.22	1.31	<5	<5	15	13	70	65	0	0
Network average		1.19	1.18	<5	<5	19	19	73	78	0	0

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[a] Barium-140 analyses were also conducted but all results were zero.

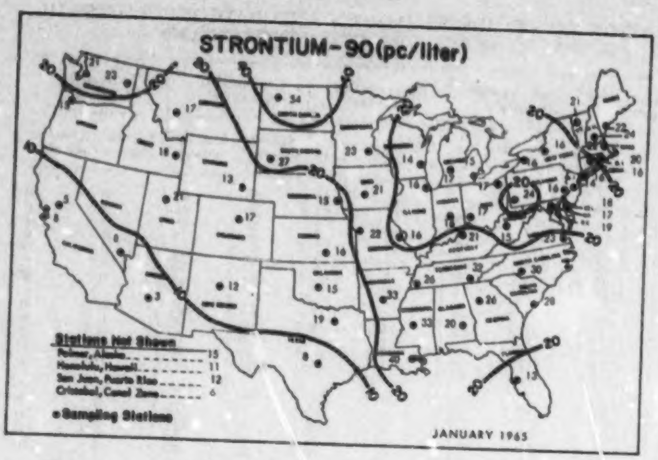
STRONTIUM-90(pc/liter)
Stations Not Shown
Palmer, Alaska 15
Honolulu, Hawaii 11
San Juan, Puerto Rico 12
Cristobal, Canal Zone 6
Sampling Stations
JANUARY 1965

FIGURE 1.—STRONTIUM-90 CONCENTRATIONS IN PASTEURIZED MILK, JANUARY 1965

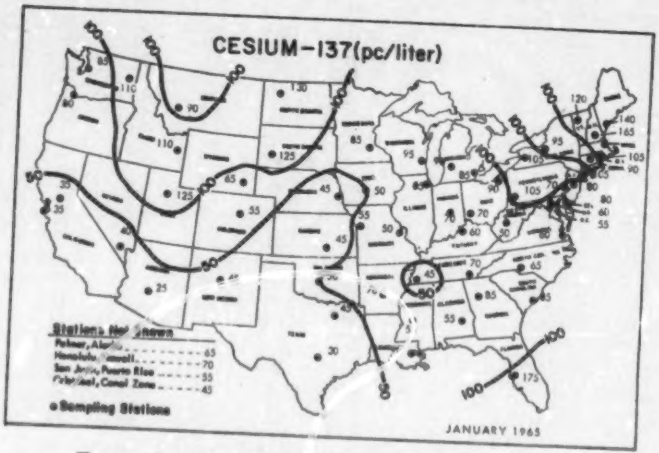
CESIUM-137(pc/liter)
Stations Not Shown
Palmer, Alaska 65
Honolulu, Hawaii 70
San Juan, Puerto Rico 55
Cristobal, Canal Zone 45
Sampling Stations
JANUARY 1965

FIGURE 2.—CESIUM-137 CONCENTRATIONS IN PASTEURIZED MILK, JANUARY 1965

TABLE 3.—RANGES OF STATION MONTHLY AVERAGES FOR STRONTIUM-90, AUGUST-DECEMBER 1964; JANUARY 1965 AND JANUARY 1964

Strontium-90 range (pc/liter)	Number of stations in range						
	1964					1965	1964
	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Jan.
Under 10	7	8	6	6	8	6	4
10-19	23	27	37	31	29	32	10
20-29	23	20	13	19	20	19	32
30-39	6	6	7	6	4	4	13
40-49	4	2	0	1	2	1	3
50-59	0	0	0	0	0	1	0
60-69	0	0	0	0	0	0	1
70-79	0	0	0	0	0	0	0

TABLE 4.—RANGES OF STATION MONTHLY AVERAGES FOR CESIUM-137, AUGUST-DECEMBER 1964; JANUARY 1965 AND JANUARY 1964

Cesium-137 range (pc/liter)	Number of stations in range						
	1964					1965	1964
	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Jan.
Under 50	6	14	16	15	9	11	2
50-99	30	33	40	41	38	38	13
100-149	19	13	6	4	14	12	25
150-199	6	2	0	2	2	2	16
200-249	1	1	1	1	0	0	5
250-349	1	0	0	0	0	0	2

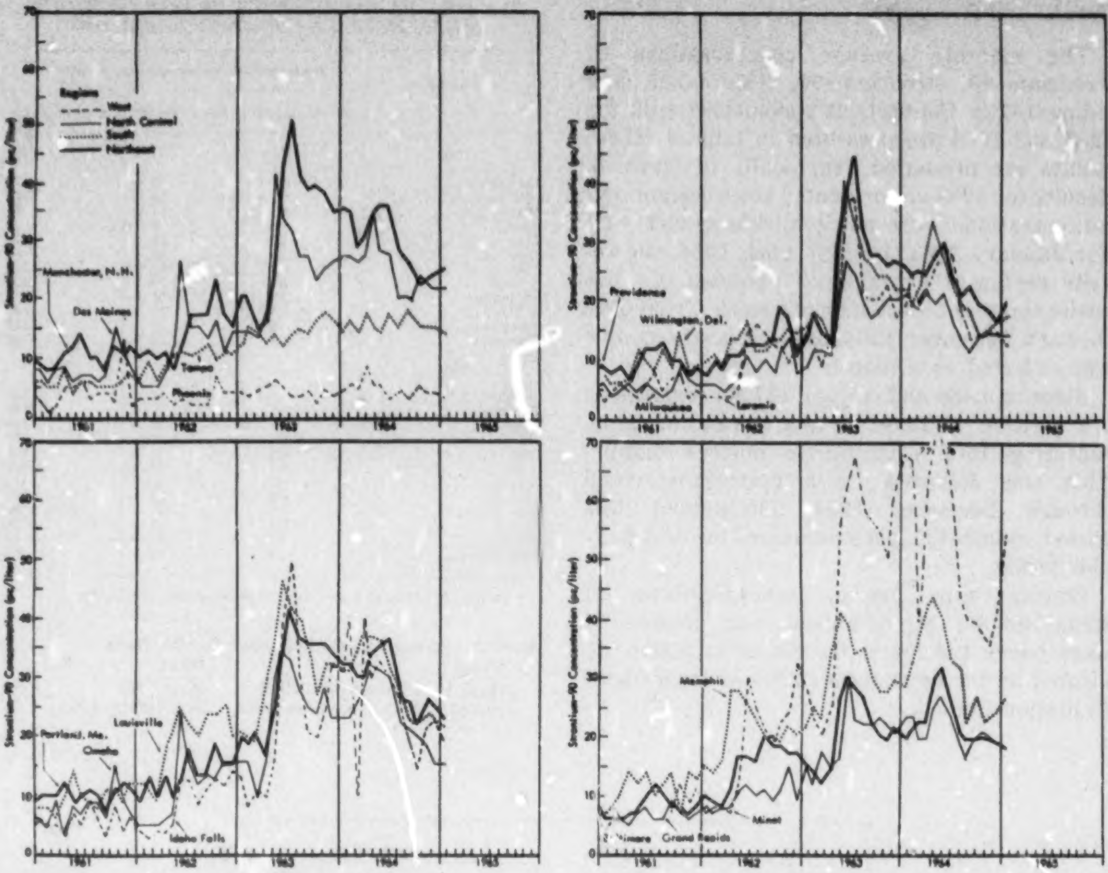

FIGURE 3.—STRONTIUM-90 IN PASTEURIZED MILK, 1961—JANUARY 1965

2. Connecticut Milk Network January—December 1964

Connecticut State Department of Health

The Connecticut State Department of Health has been monitoring pasteurized milk for strontium-89 and strontium-90 since April 1960. In May 1962 the Connecticut Milk Network program was expanded to include the determination of gamma emitting radionuclides in milk.

The sampling program is flexible in nature. Under this program, up to five areas of the State (figure 4) have been sampled at a frequency up to twice a week. Presently, a monthly sample representative of milk sold in the central area of the State is collected and analyzed for strontium-89, strontium-90, and gamma emitters. Concentrations of iodine-131 are followed as an indication of the presence of radioactivity of recent origin.

Analytical procedures

Strontium-89 and strontium-90 are determined by chemical separation and subsequent counting in a low-background Geiger-Mueller counter utilizing a thin-window, gas-flow counting chamber. Iodine-131 and other gamma emitters are determined by gamma scintillation spectroscopy. The counting system consists of a 400-channel pulse height analyzer and a 4 x 4-inch sodium iodide (thallium activated) crystal detector.

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Results and discussion

The monthly average concentrations of strontium–89, strontium–90, cesium–137, and iodine–131 in Connecticut pasteurized milk for 1963 and 1964 are presented in table 5. These results are presented graphically in figure 5. Results for 1963 are presented since cesium–137 concentrations were not available earlier (*3*). For January 1963 through April 1964, the results represent averages of analyses of composite samples collected once a week; from May through December 1964, one composite sample was collected each month.

Strontium–89 and cesium–137 concentrations are seen to increase in the spring of 1963, reflecting 1962 atmospheric nuclear testing. This was followed by a decreasing trend through December 1964. Throughout this period, iodine–131 levels remained below detectable levels.

During this period, concentrations of strontium–89, strontium–90 and iodine–131 were below the levels for remedial action indicated by the recommendations of the Federal Radiation Council.

TABLE 5.—RADIONUCLIDES IN CONNECTICUT MILK, JANUARY 1963–DECEMBER 1964

Month	Radionuclide concentrations, pc/liter [a]		
	Strontium-89	Strontium-90	Cesium-137
1963			
January	1	8.9	70
February	2	8.9	70
March	<1	11.0	70
April	1	8.8	60
May	27	12.6	110
June	48	20.1	180
July	67	30.0	220
August	47	28.9	200
September	13	26.6	150
October	15	17.9	130
November	8	21.3	150
December	<1	22.9	160
1964			
January	2.7	18.2	160
February	7.7	19.8	160
March	<1	20.5	160
April	<1	19.9	150
May	<1	18.8	160
June	<1	22.5	120
July	<1	20.4	120
August	<1	17.1	100
September	<1	11.5	80
October	<1	13.8	70
November	<1	14.0	70
December	<1	12.3	80

[a] Iodine-131 levels all below limit of detectability, 10 pc/liter.

Recent coverage in *Radiological Health Data:*

Period	Issue
April 1960–December 1962	*May 1963*
January 1963–December 1963	*September 1964*

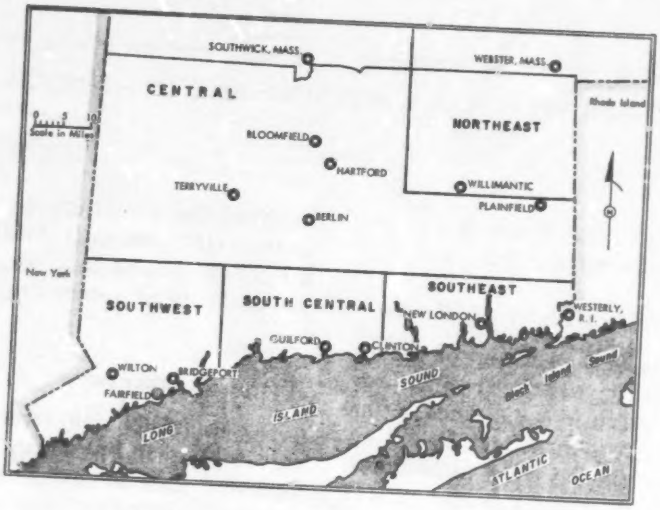
SOUTHWICK, MASS.
WEBSTER, MASS.
CENTRAL
Rhode Island
0 5 10
Scale in Miles
BLOOMFIELD
NORTHEAST
HARTFORD
TERRYVILLE
WILLIMANTIC
PLAINFIELD
BERLIN
New York
SOUTHEAST
SOUTHWEST
SOUTH CENTRAL
NEW LONDON
WESTERLY, R.I.
GUILFORD
CLINTON
WILTON
BRIDGEPORT
FAIRFIELD
SOUND
Block Island Sound
LONG
ISLAND
ATLANTIC
OCEAN

FIGURE 4.—CONNECTICUT MILK SAMPLING STATIONS

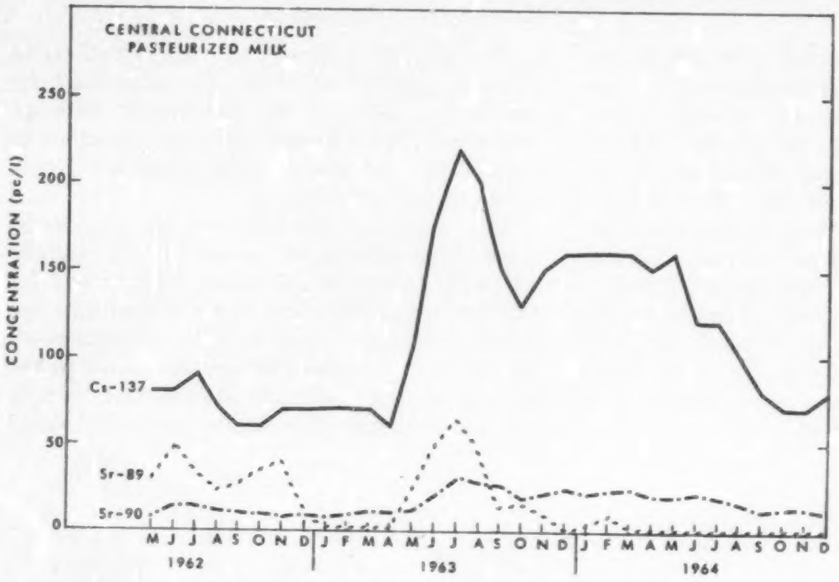

FIGURE 5.—RADIONUCLIDES IN CONNECTICUT MILK

3. Indiana Milk Network
September—December 1964

Bureau of Environmental Sanitation,
Indiana State Board of Health

The Indiana State Board of Health began sampling pasteurized milk for radionuclide analysis in September 1961. To analyze radionuclide concentrations in Indiana milk effectively, the State was geographically divided into 5 major milksheds: Northeast, Northwest, Central, Southeast, and Southwest (figure 6). One large dairy within each milkshed was assumed to be representative for sampling purposes.

The milk samples are routinely analyzed for strontium-89, strontium-90, cesium-137, iodine-131, and barium-140. Initially, cesium-137, iodine-131, and barium-140 were analyzed weekly. When iodine-131 concentrations exceeded 100 pc/liter, the sampling frequency was increased. Since August 1963, because of the continued low concentrations of short-lived radionuclides, the sampling frequency was reduced to once per month for the Northeast, Southeast, and Southwest milksheds. Monthly analyses for strontium-89 and strontium-90 are performed at each station.

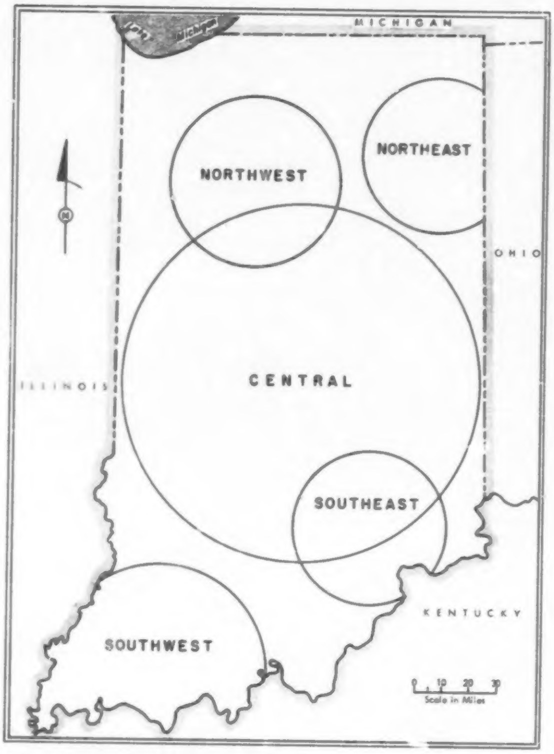

FIGURE 6.—INDIANA MILK SAMPLING LOCATIONS

Analytical procedures

Strontium–89 and strontium–90 concentrations in milk samples are determined by ion-exchange separation (*5, 6*) and subsequent low background beta counting. The limits of detectability for strontium–89 and strontium–90 are 5 and 1 pc/liter, respectively. Cesium–137, iodine–131, and barium–140 are determined by gamma spectroscopy. The counting system consists of a 512-channel pulse height analyzer and a shielded 4 x 4-inch sodium iodide crystal detector. The limit of detectability for both barium–140 and iodine–131 is 5 pc/liter. Cesium–137 concentrations are subject to a 6 percent error at 100 pc/liter.

Results and discussion

The monthly radionuclide concentrations in Indiana pasteurized milk are presented by station in table 6 for September through December 1964. The monthly concentrations of iodine–131 and barium–140 remained below limits of detectability.

The monthly network average concentrations of strontium–89, strontium–90, iodine–131, and cesium–137 are presented in table 7 for October 1961 to December 1964. These data are presented graphically in figure 7. Strontium–89 and iodine-131 concentrations increased in the spring of 1962 following atmospheric nuclear testing. Subsequently these levels decreased

TABLE 6.—RADIONUCLIDE CONCENTRATIONS IN INDIANA MILK, SEPTEMBER—DECEMBER 1964

Sampling location	Calcium, g/liter				Potassium-40, pc/liter				Strontium-89, pc/liter				Strontium-90, pc/liter				Cesium-137, pc/liter			
	Sept	Oct	Nov	Dec	Sept	Oct	Nov	Dec	Sept	Oct	Nov	Dec	Sept	Oct	Nov	Dec	Sept	Oct	Nov	Dec
Northeast	1.24	1.21	1.20	1.16	1290	1300	1290	1310	0	0	0	15	12	18	16	12	55	75	65	65
Southeast	1.18	1.18	1.26	1.16	1270	1340	1340	1340	0	0	0	0	13	15	14	22	50	55	55	70
Central	1.18	1.18	1.26	1.16	1310	1330	1330	1370	0	0	0	0	14	11	12	14	50	55	55	65
Southwest	1.20	1.15	1.26	1.16	1250	1350	1290	1410	0	0	0	0	17	17	17	18	40	50	50	70
Northwest	1.22	1.18	1.26	1.16	1320	1320	1290	1380	0	0	0	0	15	13	14	14	60	60	65	75
Average	1.20	1.19	1.25	1.16	1290	1330	1310	1360	0	0	0	5	14	15	15	16	50	60	60	70

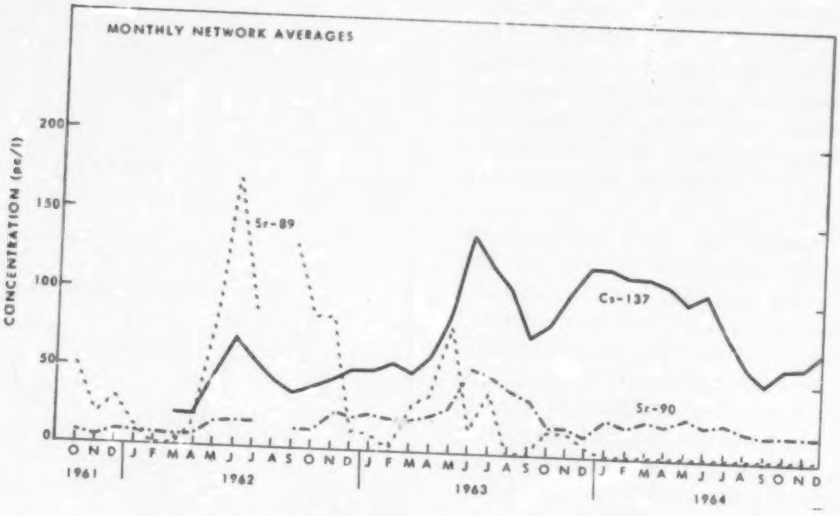

FIGURE 7.—RADIONUCLIDE CONCENTRATIONS IN INDIANA PASTEURIZED MILK NETWORK

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until by the end of 1963 they were below detectable levels. Strontium-90 and cesium-137 concentrations also increased following 1962 atmospheric nuclear testing to a peak in the summer of 1963. With the subsequent cessation of atmospheric nuclear testing, these levels began a downward trend.

During the period covered, concentrations did not reach levels that required countermeasures based upon health implications. Criteria for such remedial action have been outlined by the Federal Radiation Council (7).

TABLE 7.—MONTHLY AVERAGE RADIONUCLIDE CONCENTRATIONS IN INDIANA MILK, OCTOBER 1961–DECEMBER 1964

Month and year	Radionuclide concentrations, pc/liter			
	Strontium-89	Strontium-90	Iodine-131	Cesium-137
1961				
October	50	7		
November	20	3		
December	30	8		
1962				
January	10	7		
February	[a] ND	7		
March	ND	6	ND	20
April	15	7	ND	20
May	75	16	30	45
June	170	16	40	70
July	90	16	20	55
August	[b] NA	NA	20	40
September	130	12	100	35
October	85	11	60	40
November	85	23	80	45
December	25	20	20	50
1963				
January	10	21	ND	50
February	ND	17	ND	55
March	30	18	ND	50
April	35	23	ND	60
May	80	30	ND	90
June	15	54	ND	140
July	40	49	ND	120
August	ND	41	ND	105
September	ND	36	ND	75
October	15	18	ND	85
November	10	18	ND	105
December	5	14	ND	120
1964				
January	ND	25	ND	120
February	ND	16	ND	115
March	ND	23	ND	115
April	ND	17	ND	110
May	ND	26	ND	100
June	ND	21	ND	105
July	ND	23	ND	80
August	ND	17	ND	60
September	ND	14	ND	50
October	ND	15	ND	60
November	ND	15	ND	60
December	5	16	ND	70

[a] ND means not detectable.
[b] NA indicates no analysis.

4. Washington Milk Network,[3] July—December 1964

Air Sanitation and Radiation Control Section
State of Washington Department of Health

The Washington State Department of Health initiated a surveillance program for radioactivity in raw milk in December 1962. The collection points shown in figure 8 were selected to provide samples representative of varying climatological conditions within the State's two major milksheds. As this sampling program also provides representation of a large percentage of the population's milk supply in the State, it would provide a basis for initiating countermeasures. In addition to sampling milk from eight locations in Washington, milk from northwest Idaho (Sandpoint) is included in the network as this area forms a part of the Spokane milkshed. Several additional points are sampled from time to time.

Raw milk samples are normally collected monthly from individual tankers, but the sampling frequency is flexible. Increased sampling can be initiated immediately if the need should arise.

Analytical procedures

All milk samples are placed in a 2-liter stainless steel Marinelli beaker and gamma-scanned for 100 minutes with a 512-channel pulse height analyzer. This beaker, which is placed on a 3 x 3-inch NaI (T1) crystal, provides equal sample thickness on all sides and top of the crystal. A 4 x 4 matrix is used to analyze the spectra and provide rapid quantitative results for iodine-131, barium-140, cesium-137, and potassium-40.

As a check of analyzer stability, daily one-minute counts of a cesium-137 standard are made. As a check on detector resolution, weekly 10-minute counts are made with the same source. Gamma efficiencies and detectability limits are given in table 8 for this system.

Following gamma scanning, selected samples are analyzed for strontium-90. After the addition of a strontium carrier, the milk proteins are precipitated with trichloroacetic acid.

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[3] Data from *Environmental Radiation Surveillance in Washington State*, Third Annual Report, August 1964.

TABLE 8.—BETA AND GAMMA EFFICIENCIES AND LIMITS OF DETECTABILITY, WASHINGTON MILK NETWORK

	Energy band (Mev)	Efficiency (percent)	Average background [a] (pc)	Limits of detectability (pc)
Gamma				
K^{40}	1.37–1.55	0.18	2277	325
I^{131}	0.33–0.40	4.20	300	20
Cs^{137}	0.62–0.72	2.60	246	30
Ba^{140}	0.46–0.57	3.50	326	30
Beta				
Y^{90}	—	37	0.6	0.24

[a] Counts per minute expressed as pc.

Oxalic acid is then added to the sample to precipitate the alkaline earths as oxalates (pH 3.0). The oxalates are ashed, dissolved in 6 *N* hydroachloric acid, and the pH adjusted to 1.4. A double extraction using an equal volume of 20 percent di-(2-ethylhexyl) phosphoric acid (HDEHP) in toluene is performed. This effectively removes rare earth activity, including yttrium-90, leaving the strontium-90 in the sample. This sample is stored for a minimum of two weeks to allow yttrium-90 to ingrow. Subsequently, the yttrium-90 is extracted with 5 percent HDEHP in toluene. The organic layer is scrubbed with an HCl solution (pH 1.4) and back extracted with 3N HNO_3. The resulting nitric acid solution is evaporated and the yttrium-90 is counted. From this the strontium-90 activity is calculated. The yttrium-90 counting is done in a low-background gas-flow internal proportional counter.

As a part of the laboratory's quality control program, some samples are split and analyzed several times. Split samples are also exchanged with State, Federal, and university laboratories for analyses and comparisons.

Results

Table 9 presents the monthly average radionuclide concentrations in Washington raw milk for July through December 1964. The results are given for representative production areas within the major milksheds.

During this period the iodine-131 and barium-140 concentrations remained below detectable levels, except for two samples in November, as shown in table 10. These samples are presumed to reflect the mainland China atmospheric nuclear detonation of October 16, 1964.

Zinc-65 was observed on four occasions in Benton County between October 6 and November 13, 1964, (varying from 91 to 122 pc/liter). Zinc-65 was also observed in Franklin County on October 19, 1964, at a concentration of 91 pc/liter. This isotope has shown up routinely in these counties and results from irrigation of some pasture land with Columbia River water which, on occasion, has been shown to contain zinc-65.

In order to visualize general trends in strontium-90 and cesium-137 concentrations in Washington milk, monthly average network concentrations are presented graphically in figure 9. These averages are not weighted according to the volume of milk from each production area nor do they take into consideration the absence of samples from several stations for a particular month.

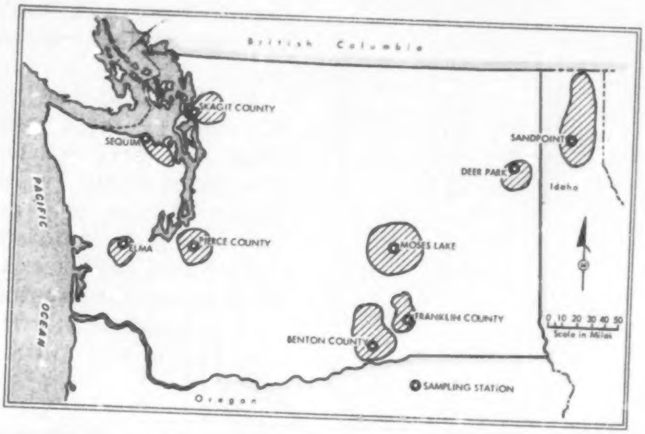

FIGURE 8.—WASHINGTON MILK SAMPLING LOCATIONS

TABLE 9.—RADIONUCLIDE CONCENTRATIONS IN WASHINGTON MILK, JULY-DECEMBER 1964

Sampling station [b]	Potassium-40, pc/liter [a]					
	July	Aug	Sept	Oct	Nov	Dec
Benton Co	NS	1090	1160	1230 (2)	1220 (4)	1210
Deer Park	[c] NS	1180	1190 (2)	1230 (3)	1190 (4)	1230
Elma	1220	NS	1240 (2)	1280	1220 (3)	1240
Franklin Co	1230	NS	NS	1180	1150 (2)	NS
Moses Lake	NS	1140	1220 (2)	1190 (3)	1190 (4)	1160
Pierce Co	1270	NS	1150 (2)	1210 (3)	1200 (3)	1250
Sandpoint	NS	1230	1290 (2)	1250 (5)	1180 (6)	1270
Sequim	1230	NS	1200 (2)	1160 (3)	1120 (3)	1260
Skagit Co	1100	NS	1210 (2)	1160 (6)	1170 (6)	1080
Network average	1210	1160	1210	1200	1180	1210
Maximum	1270	1230	1340	1330	1350	1270
Minimum	1100	1090	1110	1110	1040	1080
	Strontium-90, pc/liter					
Benton Co	NS	[d] NA	9	NA	9	8
Deer Park	NS	15	20	13 (2)	22	26
Elma	22	NS	14	21	16	29
Franklin Co	8	NS	NS	9	NA	NS
Moses Lake	NS	7	10	8 (2)	8	8
Pierce Co	27	NS	29 (2)	20 (2)	16	18
Sandpoint	NS	31	34 (2)	30 (3)	28 (4)	20
Sequim	19	NS	12	13 (2)	17	21
Skagit Co	27	NS	10	25 (4)	23 (2)	20
Network average	21	18	20	19	21	19
Maximum	27	31	34	25	28	29
Minimum	8	7	9	7	8	8
	Cesium-137, pc/liter					
Benton Co	NS	73	71	50 (2)	60 (4)	45
Deer Park	NS	138	107 (2)	94 (3)	134 (4)	127
Elma	210	NS	103 (2)	122	91 (3)	182
Franklin Co	69	NS	NS	49	66 (2)	NS
Moses Lake	NS	46	59 (2)	49 (3)	55 (4)	56
Pierce Co	259	NS	300 (2)	144 (3)	119 (3)	71
Sandpoint	NS	209	204 (2)	148 (5)	161 (6)	148
Sequim	138	NS	74 (2)	71 (3)	114 (3)	119
Skagit Co	173	NS	100 (2)	128 (6)	108 (6)	143
Network average	169	117	131	104	107	111
Maximum	259	209	368	186	173	182
Minimum	69	46	56	35	45	45

[a] Parentheses indicate number of samples in average.
[b] All stations are in Washington except, Sandpoint, Idaho.
[c] NS indicates no sample collected.
[d] NA indicates no analysis performed.

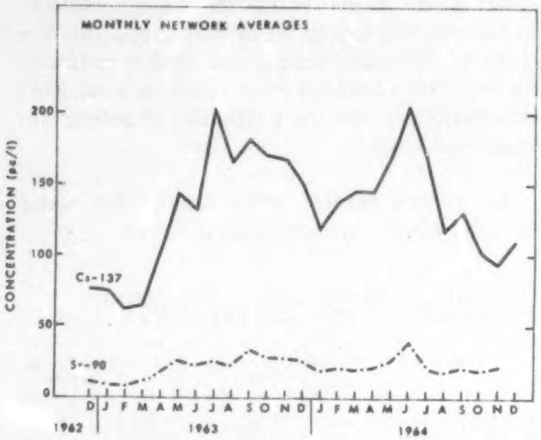

FIGURE 9.—MONTHLY AVERAGE RADIONUCLIDE CONCENTRATIONS IN WASHINGTON MILK

TABLE 10.—MILK SAMPLES REFLECTING CHINESE TEST FALLOUT

Station	Date	Radionuclide concentrations	
		Iodine-131 (pc/liter)	Barium-140 (pc/liter)
Sequim	Nov. 10, 1964	12	<15
Skagit Co	Nov. 10, 1964	<10	17

5. Canadian Milk Network[4]
January 1965

Radiation Protection Division, Department of National Health and Welfare, Ottawa, Canada

The Radiation Protection Division of the Department of National Health and Welfare began monitoring milk for strontium-90 in November 1955. At first, analyses were carried out on samples of powdered milk obtained from processing plants. However, since January 1963, liquid whole milk has been analyzed instead. With this change, more representative samples of milk consumed can be obtained, and milk sampling locations (figure 10) may be chosen in the same areas as the air and precipitation stations. At present the analyses include determinations of iodine-131 strontium-89, cesium-137, and strontium-90 as well as stable potassium and calcium.

The milk samples are obtained through the cooperation of the Marketing Division of the Canadian Department of Agriculture. At each station samples are collected three times a week from selected dairies, combined into weekly composites, and forwarded to the radiochemical laboratory in Ottawa. Each dairy contributes to the composite sample in proportion to its

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[4] Data from *Radiation Protection Programs*, Vol. 3, No. 2: 25-26. Radiation Protection Division, Canadian Department of National Health and Welfare (February 1965).

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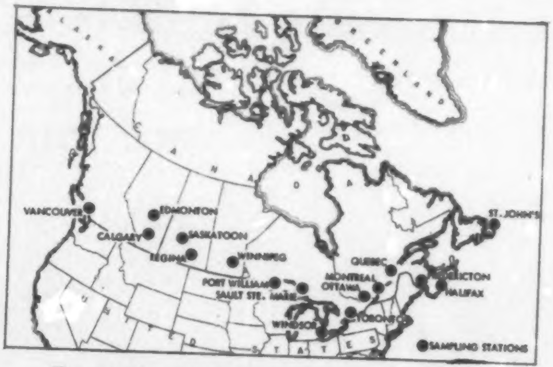

FIGURE 10.—CANADIAN MILK SAMPLING STATIONS

volume of sales. In most cases a complete sample represents over 80 percent of the milk processed and distributed in the area. Several of the weekly samples are randomly selected and analyzed for iodine–131. The results of the spot checks for iodine–131 will not be reported unless there is evidence that the levels are rising. A monthly composite of the samples is analyzed for strontium–90, cesium–137, and stable potassium and calcium.

Analytical methods

Radiochemical methods are used for the analysis of iodine–131 (*8*). For the analysis of radiostrontium, carrier strontium is added to a one-liter sample of milk. The milk is then placed in a tray (lined with a polyethylene sheet) and evaporated under infra-red lamps. The residue is placed in a muffle furnace at 450 degrees C. and the resulting ash dissolved in dilute nitric acid. Strontium is separated by fuming nitric acid precipitation. The combined strontium–89 and strontium–90 are determined by counting in a low-background beta counter. Strontium–90 is determined separately by extracting and counting its yttrium–90 daughter, while strontium–89 is estimated by difference from the total radiostrontium measurement. Appropriate corrections are made for self-absorption and counter efficiency at all stages. Calcium is determined by flame photometry.

Cesium–137 is determined by gamma spectroscopy using a scintillation crystal and a multichannel pulse height analyzer. A sample consisting of 4.5 liters of milk is placed in a sample tray constructed in the form of an inverted well to accommodate the 5 x 4-inch sodium iodide crystal detector. The sample is counted with the latter for 100 minutes and the gamma spectrum recorded. Estimates are made of the potassium–40 and cesium–137 content of the milk by comparison of the spectrum with the spectra of standard preparations of these two radionuclides. With this method the potassium–40 concentration is determined, and the Compton contribution of this radionuclide to the cesium–137 photopeak is substracted to obtain the cesium–137 concentration. The stable potassium content is estimated from the potassium–40 concentration.

Sources of error

In the iodine and strontium determinations, tests indicate that the statistical error (95 percent confidence level) in the chemical operations involved is about plus-or-minus 10 percent. This value is independent of the concentration of the radioisotope in the milk because it depends only on the recovery of the carrier. In the determination of cesium–137 this factor is not involved.

The chemical procedures error must be combined with the counting error which depends primarily on the concentration of the nuclide in the sample, the background radiation, and the length of time the sample and background are counted. This counting error has been evaluated mathematically for the particular counting arrangement used.

The overall errors, estimated on the basis indicated above, are given in table 11.

TABLE 11.—TOTAL ERROR FOR VARIOUS RADIONUCLIDE CONCENTRATIONS IN MILK [a]

Nuclide	Error for 10 pc/liter	Error for 50 pc/liter	Error for 100 pc/liter
Strontium-89	±50%	±20%	±10%
Strontium-90	±15%	±10%	±10%
Iodine-131	±25%	±20%	±15%
Cesium-137	±60%	±25%	±10%

[a] All errors are 2σ values, representing 95 percent confidence levels.

Results

Table 12 presents monthly averages of strontium-90, cesium-137, and stable calcium and potassium in Canadian whole milk.

TABLE 12.—STABLE ELEMENTS AND RADIONUCLIDES IN CANADIAN WHOLE MILK, JANUARY 1965

Station	Calcium (g/liter)	Potassium (g/liter)	Strontium-90 (pc/liter)	Cesium-137 (pc/liter)
Calgary	1.13	1.5	24.8	112
Edmonton	1.10	1.6	25.2	123
Ft. William	1.06	1.6	39.4	175
Fredericton	1.10	1.6	36.5	197
Halifax	1.06	1.6	35.4	231
Montreal	1.10	1.7	28.1	146
Ottawa	1.13	1.7	22.9	132
Quebec	1.04	1.6	43.3	247
Regina	1.06	1.6	33.7	130
St. John's, Nfld	1.06	1.5	32.8	190
Saskatoon	1.13	1.6	26.9	115
Sault Ste. Marie	1.06	1.6	35.4	181
Toronto	1.08	1.7	14.2	90
Vancouver	1.15	1.6	38.1	261
Windsor	1.06	1.6	14.3	92
Winnipeg	0.84	1.7	27.3	163
Average	1.07	1.6	29.9	162

6. Pan American Milk Sampling Program, September 1963—December 1964

Pan American Health Organization, and Public Health Service

In accordance with a joint agreement, the PAHO (Pan American Health Organization) and the PHS (Public Health Service), developed a collaborative program for furnishing assistance to health authorities in the Americas engaged in developing programs in radiological health.

Under this agreement, the PHS Division of Radiological Health furnishes to PAHO, on a loan basis, limited quantities of essential items of equipment and the requisite laboratory services to establish a surveillance program.

Sampling procedure

Initially, air sampling stations were established in Chile, Jamaica, Peru, and Venezuela. In August 1963 this was expanded to include a milk sampling station in Caracas, Venezuela. Between April 1964 and August 1964, milk stations were added in Jamaica at Kingston, Montego Bay, and Mandeville. Sampling varies according to local procedures.

Under the direction of the Venezuelan Institute for Scientific Investigation, weekly samples are collected, preserved with formaldehyde and sent to the PHS Southeastern Radiological Health Laboratory for biweekly compositing and analysis.

Jamaica, under the direction of the Ministry of Health, collects one monthly composite on a rotating basis from one of the three principal milk areas: Montego Bay (Montpelier), Mandeville, and Kingston (Spanish Town). To reduce spoilage it was necessary to establish cooling stations in the western parishes where the milk is received prior to shipping to the condensery in Kingston.

Analytical procedures

Iodine-131 and cesium-137 are determined by gamma scintillation spectroscopy. Strontium-89, strontium-90, and barium-140 are determined radiochemically. There is an inherent statistical variation associated with all measurements of radionuclide concentrations. With the low radionuclide levels which are usually found in milk and other environmental samples, this variation (on a percentage basis) is relatively high. The variation depends upon such factors as the method of chemical analysis, the sample counting rate and counting time, interference from other radionuclides, and background count. For milk samples, counting times of 50 minutes for gamma spectroscopy and 30 to 50 minutes for beta determinations are used. Table 1 (p. 250) shows the approximate total analytical error (including counting error) associated with radionuclide concentrations in milk. These errors were determined by comparing results of a large number of replicate analyses. Table 1 gives the 95-percent confidence limits between which the true concentrations of the selected radionuclides might be expected in the analyses. The minimum detectable concentration is defined as the measured concentration at which the two-standard-deviation analytical error is equal to the measurement. Accordingly, the minimum detectable concentration in units of pc/liter are Sr^{89}, 5; Sr^{90}, 2; Ba^{140}, 10; Cs^{137}, 10; and I^{131}, 10. At these levels and below, the counting error comprises nearly all of the analytical error. Calcium analyses are done by an ion-exchange and permanganate titration method. Stable potassium concentrations are estimated from the potassium-40 concentrations[5] determined from the gamma spectrum.

Data presentation

Table 13 presents stable calcium and potassium, strontium-89, strontium-90, and cesium-137 monthly average concentrations in milk to date. Iodine-131 and barium-140 monthly average concentrations in milk are not tabulated because all were below 10 pc/liter. For comparison purposes the radionuclide concentrations at Cristobal, Canal Zone, and San Juan, Puerto Rico are presented.

Variations in cesium-137 levels between Montego Bay and Kingston (Spanish Town), Jamaica, have been attributed in part to differences in rainfall. The average rainfall in the Montego Bay milkshed is 75 to 200 inches, while in the other milksheds it ranges from 50 to 100 inches. Consideration of the farming practices leads to the conclusion that the differences in cesium levels can be attributed to a combination of environmental factors such as rainfall, soil leaching variations, and native grass differences.

TABLE 13.—CALCIUM, POTASSIUM, AND RADIONUCLIDE CONCENTRATIONS IN PAN AMERICAN MILK, AUGUST 1963–DECEMBER 1964

Sampling stations and months	Concentrations g/liter		Radionuclide concentrations, pc/liter		
	Calcium	Potassium	Strontium-89	Strontium-90	Cesium-137
Canal Zone:					
Cristobal					
December 1964	1.16	1.4	<5	6	45
Jamaica:					
Kingston (1964)					
April	1.19	1.49	<5	24	345
May	[a] NS	NS	NS	NS	NS
June	1.18	1.35	<5	20	170
July	NS	NS	NS	NS	NS
August	NS	NS	NS	NS	NS
September	1.15	1.45	<5	12	165
October	NS	NS	NS	NS	NS
November	NS	NS	NS	NS	NS
December	1.24	1.39	<5	14	205
Mandeville (1964)					
July	1.20	1.42	<5	10	280
August	NS	NS	NS	NS	NS
September	NS	NS	NS	NS	NS
October	1.24	1.40	<5	13	265
November	NS	NS	NS	NS	NS
December	NS	NS	NS	NS	NS
Montego Bay (1964)					
May	1.24	1.42	<5	36	555
June	NS	NS	NS	NS	NS
July	NS	NS	NS	NS	NS
August	1.10	1.48	<5	16	660
September	NS	NS	NS	NS	NS
October	NS	NS	NS	NS	NS
November	1.21	1.35	<5	19	525
Puerto Rico:					
San Juan (1964)					
December	1.16	1.5	<5	10	50
Venezuela:					
Caracas (1963)					
August	1.14	1.40	10	5	15
September	1.13	1.45	<5	5	20
October	NS	NS	NS	NS	NS
November	1.18	1.38	<5	4	25
December	1.08	1.27	<5	6	30
1964					
January	1.16	1.39	<5	5	20
February	1.18	1.34	<5	6	25
March	1.10	1.54	<5	6	25
April	1.08	1.47	<5	6	35
May	1.15	1.46	<5	6	20
June	1.12	1.61	<5	6	25
July	1.10	1.44	<5	8	40
August	1.14	1.45	<5	5	30
September	1.12	1.54	<5	8	30
October	1.16	1.44	<5	6	20
November	1.18	1.36	<5	5	20

[a] NS indicates no sample collected.

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[5] The conversion factor is 1.18 x 10−3 g K/pc K^{40}.

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APPLICATION OF RADIONUCLIDE CONCENTRATIONS IN MILK TO INTAKE GUIDES, FEBRUARY 1964–JANUARY 1965

Division of Radiological Health, Public Health Service

The concentrations of specific radionuclides in milk analyzed as part of the Pasteurized Milk Network (PMN) is reported on a monthly basis in *RHD*. In terms of radiological health surveillance activities, an important aspect of these data is the estimation of resultant radiation dose to population groups.

Approximate relationships between certain radionuclide intakes and dose have been applied to the formulation of daily intake guides (*1*) and permissible concentrations in selected environmental media (*2*). Although these guides are not themselves directly applicable to worldwide fallout, a comparison with environmental contamination levels does yield a measure of population dosage. In general, intake-dose and dose-biological effect relationships used in formulating the guides cited are based on continuous intake over an entire lifetime. However, for general surveillance purposes, yearly average intakes, used with discretion, may be compared directly with the levels adopted as lifetime intake guides. Thus, the radionuclide concentrations in milk, averaged over a year's time, together with milk consumption data, might be used in conjunction with the references cited above to approximate the radiation dose to a specific population group from a specific radionuclide. Table 1 presents annual averages of radionuclide concentrations in milk sampled by the *PMN*. Limited data are available for estimating the average daily milk consumption (on a volume basis) for specific age groups in the U.S. population (*3, 4*).

Total dietary intake is of prime interest, and since the intake via milk consumption constitutes only a portion of the total radionuclide intake, the relationship of milk intake to total dietary intake is of importance in evaluating milk surveillance data. The Federal Radiation Council (*5*) notes: "A number of studies have shown that conservative estimates of the strontium–90 to calcium ratio in the total diet may be made by multiplying the ratio of strontium–90 to calcium in milk in a particular locality by 1.5".[1] Thus, a rough index of the total dietary intake of strontium–90 on an annual basis may be made from PMN annual averages by using this factor and the assumptions of approximately 1.2 g of calcium per liter in PMN samples and a 1.0 g daily intake of calcium.

In the case of iodine–131, milk can be considered the major source because of the rapid distribution and consumption of fresh milk. With most other foods, normal processing and distribution allows time for the radioactive decay of this short-lived nuclide to insignificant levels.

The situation with respect to strontium–89 is more complicated. Its half-life of some 50 days makes it difficult to estimate the relative contribution made by sources other than milk to the total dietary intake.

The relative contribution of milk to the total dietary intake of cesium–137 is not well defined and depends principally on the amount of freshly deposited cesium–137 on products used for human and animal consumption, and the progress of cesium–137 through the food chain.

The data in table 1 are calculated as follows: results from all samples collected in each week (Sunday through Saturday) are averaged, and the averages for all weeks terminating in each of twelve consecutive months are averaged to obtain the annual average.[2] To obtain the annual average daily intake (pc/day) of radionuclides from milk, the annual average concentration values (pc/liter) in table 1 must be multiplied by the annual average daily consumption (liters/day) of milk.

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[1] This ratio may vary from 1 to 2, depending on changes in rate of fallout deposition and relative consumption of non-milk products whose contamination reflect temporal and local deposition patterns (*6*).

[2] Beginning with the October 1963 data, iodine–131 values of <10 pc/liter are considered to be zero for averaging purposes; previously, 5 pc/liter was used for calculating the averages.

TABLE 1.—AVERAGE RADIONUCLIDE CONCENTRATIONS IN MILK, FOR THE TWELVE MONTH PERIODS JANUARY 1964–DECEMBER 1964[a] AND FEBRUARY 1964–JANUARY 1965[b]

Sampling locations		Average radionuclide concentrations, pc/liter							
		Strontium-89		Strontium-90		Iodine-131		Cesium-137	
		Jan 1964–Dec 1964	Feb 1964–Jan 1965	Jan 1964–Dec 1964	Feb 1964–Jan 1965	Jan 1964–Dec 1964	Feb 1964–Jan 1965	Jan 1964–Dec 1964	Feb 1964–Jan 1965
Ala:	Montgomery	3	3	22	22	0	0	79	76
Alaska:	Palmer	5	5	21	20	0	0	124	115
Ariz:	Phoenix	3	3	4	4	0	0	25	25
Ark:	Little Rock	3	3	43	43	1	1	117	110
Calif	Sacramento	3	3	8	7	0	0	42	40
	San Francisco	3	3	10	10	0	0	48	44
C. Z:	Cristobal	3	3	5	5	0	0	51	50
Colo:	Denver	3	3	19	19	0	0	88	85
Conn:	Hartford	3	3	20	19	0	0	135	127
Del:	Wilmington	3	3	22	22	1	1	113	108
D. C:	Washington	3	3	19	19	0	0	79	75
Fla:	Tampa	3	3	15	15	0	0	231	229
Ga:	Atlanta	3	3	31	31	0	0	130	125
Hawaii:	Honolulu	3	3	12	12	0	0	77	76
Idaho:	Idaho Falls	10	9	26	25	0	0	154	146
Ill:	Chicago	3	3	19	18	0	0	100	104
Ind:	Indianapolis	3	3	20	19	1	1	91	87
Iowa:	Des Moines	4	4	25	24	0	0	83	78
Kans:	Wichita	4	4	21	20	0	0	63	60
Ky:	Louisville	3	3	30	29	0	0	81	76
La:	New Orleans	4	3	50	49	0	0	135	127
Maine:	Portland	3	3	29	28	1	1	187	179
Md:	Baltimore	3	3	22	22	0	0	90	86
Mass:	Boston	3	3	31	30	0	0	203	192
Mich:	Detroit	3	3	18	18	2	2	105	100
	Grand Rapids	3	3	21	20	1	1	116	112
Minn:	Minneapolis	7	6	31	30	0	0	135	127
Miss:	Jackson	4	4	40	40	0	0	99	93
Mo:	Kansas City	5	5	27	26	0	0	73	69
	St. Louis	4	4	22	22	0	0	74	70
Mont:	Helena	5	4	25	24	1	1	157	145
Nebr:	Omaha	4	3	25	24	0	0	87	82
Nev:	Las Vegas	3	3	10	9	1	1	70	66
N. H:	Manchester	3	3	30	29	1	1	217	209
N. J:	Trenton	3	3	19	18	1	1	109	104
N. Mex.	Albuquerque	3	3	11	11	1	1	53	52
N. Y:	Buffalo	3	3	20	19	0	0	131	126
	New York	3	3	25	24	1	1	146	139
	Syracuse	[c]3	[d]3	[c][illegible]	[d]18	[c]0	[d]0	[c]129	[d]122
N. C:	Charlotte	3	3	36	36	0	0	105	101
N. Dak:	Minot	11	10	54	53	0	0	147	144
Ohio:	Cincinnati	3	3	22	21	0	0	86	82
	Cleveland	3	3	21	20	0	0	107	103
Okla:	Oklahoma City	3	3	22	22	0	0	65	62
Ore:	Portland	5	5	30	29	0	0	149	141
Pa:	Philadelphia	3	3	20	19	0	0	110	104
	Pittsburgh	3	3	29	28	0	0	138	133
P. R:	San Juan	3	3	12	12	0	0	70	70
R. I:	Providence	3	3	23	23	0	0	150	143
S. C:	Charleston	3	3	32	32	0	0	122	119
S. Dak:	Rapid City	5	5	39	38	0	0	142	138
Tenn:	Chattanooga	4	4	40	40	0	0	111	105
	Memphis	3	3	32	32	0	0	66	64
Tex:	Austin	3	3	9	9	0	0	38	37
	Dallas	3	3	19	19	0	0	58	55
Utah:	Salt Lake City	6	6	25	24	0	0	165	159
Vt:	Burlington	3	3	25	25	2	2	162	154
Va:	Norfolk	3	3	18	18	0	0	88	85
Wash:	Seattle	6	6	26	26	0	0	144	140
	Spokane	6	5	28	26	0	0	132	128
W. Va:	Charleston	3	3	25	25	0	0	73	68
Wis:	Milwaukee	3	3	17	17	1	1	120	115
Wyo:	Laramie	7	6	20	20	0	0	101	97
Network average		4	4	23.7	23.1	0	0	109	104

[a] Annual averages were computed on basis of 52 weekly averages. Annual averages for barium-140 at each station were <10.
[b] Annual averages were computed on basis of 53 weekly averages.
[c] Annual averages were computed on basis of 48 weekly averages. No sample was collected during July 1964.
[d] Annual averages were computed on basis of 49 weekly averages. No sample was collected during July 1964.

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Monthly variations of radionuclide concentrations in milk are influenced by a number of combined causes such as meteorologic conditions and dairying practices, apart from considerations of original sources of radionuclides. The moving yearly average by one month, shows variations averaged over the year and tends to minimize purely seasonal variations.

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STRONTIUM-90 IN 1964 UNITED STATES WHEAT

V. F. Pfeifer and R. A. Anderson[1]

Studies of processing methods aimed at reducing strontium-90 in wheat and milling products are continuing at the U.S. Department of Agriculture's Northern Regional Research Laboratory. Kansas wheats from the 1963 crop year are being used in these experiments because their strontium-90 levels were the highest yet reported. Strontium-90 levels in 1963 wheats from the major U.S. wheat-producing areas, reported last year by Pfeifer and Peplinski (*1*), agreed quite well with the average of 250 pc/kg predicted by the Federal Radiation Council (*2*). At that time a value of 100 pc/kg was predicted as the probable average for 1964 wheat. This prediction was subsequently raised to 140 pc/kg based on later data for fallout and accumulation of strontium-90 in the soil at the beginning of 1964 (*3*).

A total of 77 wheat samples from the 1964 harvest was procured from 31 different locations in 11 different wheat-producing States. These 11 States represent 69 percent of the total 1964 wheat production (*4*). Each lot of wheat was blended and cleaned in a dockage tester to remove dust and chaff before analysis. Strontium-90 was determined by a modification of the method described by Harley (*5*). The samples were ashed at 1000°F; the ash was fused with sodium carbonate at 1700°F; strontium carrier was added to the suspension of fusion mixture in hot water; and insoluble carbonates were separated, washed, and recovered. The carbonates were dissolved in nitric acid, and strontium nitrate recovered after two purifications in 75 percent nitric acid, yttrium-90 was stripped out as the hydroxide with yttrium carrier, and strontium-90 with strontium carrier was recovered by carbonate precipitation. Strontium-90 was determined from a 2-week ingrowth of its daughter, yttrium-90. Analyses for protein, ash, and calcium were made by Cereal Laboratory Methods 46-10, 08-01, and 40-20, respectively (*6*).

The results, listed in table 1, show lowest levels of contamination in wheat from Washington, Oregon, Idaho, Montana, and North

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TABLE 1.—STRONTIUM-90 IN U.S. WHEATS HARVESTED IN 1964

(Calculated on dry basis [a])

Wheat class	Grown in vicinity of:	Number of samples	Nitrogen (per cent)	Ash (per cent)	Calcium (per cent)	Strontium-90 (pc/kg)
SWW [b]	Rosalia, Wash	1	1.62	1.47	0.040	91
HRW	Southeast Washington	5	2.56	1.59	—	55
HRW	North Central Oregon	2	2.21	1.78	—	53
HRW	Bonners Ferry, Idaho	1	2.35	1.61	—	41
HRW	Southern Idaho	2	2.66	1.58	—	26
HRS [c]	Cut Bank, Mont	1	2.56	1.58	0.037	132
HRS	Dutton, Mont	1	2.55	1.89	0.032	37
HRS	Bozeman, Mont	1	3.46	2.03	0.055	30
HRS	Williston, N. Dak	1	2.99	2.12	0.038	81
HRS	Carrington, N Dak	4	3.00	1.98	0.031	102
HRS	Langdon, N. Dak	1	3.06	2.23	0.036	121
HRS	Fargo, N. Dak	1	2.97	2.30	0.044	34
HRW [d]	Alliance, Nebr	5	2.88	1.62	0.045	81
HRW	Lincoln, Nebr	5	2.80	1.91	0.054	226
HRW	Garden City, Kans. (Irrigation).	5	2.57	1.73	0.055	181
HRW	Garden City, Kans. (Dry land).	6	2.93	1.88	0.056	150
HRW	Kinsley, Kans	3	2.59	2.00	0.061	227
HRW	Hays, Kans	6	2.88	1.60	0.057	232
HRW	Hutchinson, Kans	6	2.77	1.47	0.053	138
HRW	Newton, Kans	6	2.65	1.71	0.046	226
HRW	Manhattan, Kans	6	3.12	1.74	0.052	310
HRW	Peoria, Ill	2	2.00	1.95	0.049	142
SWW	Saranac, Mich	1	1.77	1.73	0.039	120
SWW	Elsie, Mich	1	2.14	2.10	0.042	139
SRW [e]	Lafayette, Ind	2	2.57	1.85	0.051	170
SRW	Wooster, Ohio	2	2.46	1.81	0.040	224

[a] Wheat moisture contents varied from 7.7 to 12.9 percent.
[b] SWW indicates soft white winter wheat.
[c] HRS indicates hard red spring wheat.
[d] HRW indicates hard red winter wheat.
[e] SRW indicates soft red winter wheat.

Dakota, and highest levels in wheat from Kansas and Ohio. The individual values ranged from a low of 26 pc/kg (dry basis) for hard red winter wheats grown in southern Idaho, to a high of 380 for an Ottawa variety of hard red winter wheat harvested near Manhattan, Kansas. The table shows large variations in levels of strontium-90 for wheats grown in the same State at different locations not too far apart. The mean values for Kansas included at least three samples from each location; for Nebraska, five samples from each location; and for Carrington, North Dakota, four samples. Standard deviations were less than 20 percent of the mean at each individual location, with most of this deviation apparently due to variety differences within the location.

Although the sampling is probably inadequate for a precise calculation of the average strontium-90 content of 1964 U.S. wheat, the results permit a reasonable estimate to be made. Projecting the values for the individual State averages (average of locations within a State), weighted by the 1964 production figures (*4*) to the entire 1964 wheat crop, the average is 133 pc/kg (dry basis) or 120 pc/kg (as-is basis). This estimate compares well with the Federal Radiation Council's predicted average value of 140 pc/kg (as-is basis) for 1964 U.S. wheat and confirms its prediction of a substantial reduction below 1963 levels.

Acknowledgments

The cooperation of the following individuals from Crops Research Division, USDA, in supplying samples of 1964 wheat is gratefully acknowledged: W. T. Yamazaki, Wooster, Ohio; W.C. Shuey, Fargo, North Dakota; M. A. Barmore, Pullman, Washington; and V. A. Johnson, Lincoln, Nebraska. Others contributing were E. G. Heyne, Kansas State University, Manhattan, Kansas, and J. E. Hubbard, Northern Division, Peoria, Illinois.

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Section III—Water

GROSS RADIOACTIVITY IN SURFACE WATERS OF THE UNITED STATES, NOVEMBER 1964

Division of Water Supply and Pollution Control, Public Health Service

Levels of radioactivity in surface waters of the United States have been monitored by the Public Health Service Water Pollution Surveillance System since its initiation in 1957. Beginning with the establishment of 50 sampling points, this system has expanded to 131 stations as of January 1965. These are operated jointly with other Federal, State, and local agencies, and industry. Samples are taken from surface waters of all major U.S. river basins for physical, chemical, biological, and radiological analyses. These data can be used for evaluating sources of radioactivity which may affect specific domestic, commercial, and recreational uses of surface water. Further, the system provides background information necessary for recognizing pollution and water quality trends and for determining levels of radioactivity to which the population may be exposed. Data assembled through the system and exact locations of sampling points are published in annual compilations (*1–7*).

Sampling procedures

The participating agencies collect one-liter "grab" samples each week and ship them "as is" to the Surveillance System Laboratory in Cincinnati for analysis. Gross alpha and gross beta radioactivity determinations on the suspended and dissolved solids are performed as frequently as deemed necessary.

Presently, gross alpha and beta determinations are made on either monthly composites of the weekly samples or on each weekly sample. Weekly alpha and beta determinations are scheduled for stations located downstream from known potential sources of radioactive waste. Weekly analyses are also conducted at all newly established stations for the first year of operation. Weekly analyses are also scheduled for selected stations in an effort to detect short term radioactivity effects from current or recent nuclear tests or events.

Normally, samples are counted within two weeks following collection or within one week after compositing. The decay of activity is followed on each sample for which the first analysis shows unusually high activity. Also, if a recount indicates that the original analysis was questionable, values based on recounting are recorded. All results are reported for the time of counting and are not extrapolated to the time of collection.

Strontium-90 analyses are performed on total solids of three-month composites of the weekly samples. The most recent strontium-90 results are presented in the March 1965 *RHD*.

Analytical methods

The analytical method used for determining gross alpha and beta radioactivity is described in the eleventh edition of "Standard

Methods for the Examination of Water and Wastewater" (*8*). Suspended and dissolved solids are separated by passing the sample through a membrane filter (type HA) with a pore size of 0.45 micron. Planchets are then prepared for counting the dissolved solids (in the filtrate) and the suspended solids (on the charred membrane filter) in an internal proportional counter. Reference sources of U_3O_8, which give a known count rate if the instrument is performing properly, are used for daily checking of the counter.

Results

Table 1 presents November 1964 results of alpha and beta analysis of U.S. surface waters. The stations on a river are arranged in the table according to their relative location on the river, the first stations listed being closest to the headwaters. These data are preliminary. Replicate analyses of some samples as well as some analyses incomplete at the time of this report will be included in the system's "Annual Compilation of Data" (*7*). The figures for gross alpha and gross beta radioactivity represent either determinations on composite samples or means of weekly determinations where composites were not made. The monthly means are reported to the nearest pc/liter. When all samples have zero pc/liter, the mean is reported as zero; when the calculated mean is between zero and 0.5 it is reported as <1 pc/liter.

TABLE 1.—RADIOACTIVITY IN RAW SURFACE WATERS, NOVEMBER 1964

Station	Beta activity, pc/liter			Alpha activity, pc/liter		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Animas River:						
Cedar Hill, N. Mex	0	13	13	0	2	2
Apalachicola River:						
Chattahoochee, Fla	2	5	7	0	0	0
Arkansas River:						
Coolidge, Kansas	9	30	39	1	19	20
Ponca City, Okla	24	17	41	1	5	6
Atchafalaya River:						
Morgan City, La	340	9	349	80	3	83
Bear River:						
Preston, Idaho	0	8	8	0	1	1
Big Horn River:						
Hardin, Mont	2	15	17	1	9	10
Big Sioux River:						
Sioux Falls, S. Dak	2	28	30	0	4	4
Chattahoochee River:						
Atlanta, Ga	4	8	12	<1	0	<1
Columbus, Ga	1	7	8	0	0	0
Lanett, Ala	2	6	8	<1	0	<1
Chena River:						
Fairbanks, Alaska	0	6	6	0	1	1
Clinch River:						
Clinton, Tenn	4	8	12	0	0	0
Kingston, Tenn	5	58	63	0	0	0
Colorado River:						
Loma, Colo	14	0	14	2	7	9
Page, Ariz	2	30	32	0	6	6
Parker Dam, Calif-Ariz	1	22	23	0	13	13
Columbia River:						
Wenatchee, Wash	1	8	9	0	1	1
Pasco, Wash	45	660	705	0	1	1
Clatskanie, Ore	17	121	138	0	<1	<1
Connecticut River:						
Enfield Dam, Conn	4	9	13	0	0	0
Coosa River:						
Rome, Ga	5	6	11	1	0	1
Cumberland River:						
Cheatham Lock, Tenn	0	4	4	0	0	0
Delaware River:						
Philadelphia, Pa	7	10	17	2	0	2
Escambia River:						
Century, Fla	3	7	10	0	0	0
Great Lakes:						
Duluth, Minn	0	6	6	0	0	0
Hudson River:						
Poughkeepsie, N.Y	0	21	21	0	2	2
Illinois River:						
Grafton, Ill	8	9	17	1	2	3
Kansas River:						
De Soto, Kans	8	18	26	4	0	4
Maumee River:						
Toledo, Ohio	1	87	88	0	0	0
Mississippi River:						
St. Paul, Minn	0	22	22	1	2	3
Dubuque, Iowa	2	19	21	0	<1	<1
E. St. Louis, Ill	0	18	18	1	1	2
Cape Girardeau, Mo	4	21	25	0	1	1
Vicksburg, Miss	8	12	20	2	1	3
New Roads, La	16	11	27	4	2	6
New Orleans, La	1	17	18	0	2	2
Missouri River:						
Williston, N. Dak	0	16	16	0	7	7
Bismark, N. Dak	2	28	30	2	3	5
Yankton, S. Dak	6	29	35	1	3	4
St. Joseph, Mo	15	21	36	5	4	9
North Platte River:						
Henry, Nebr	5	42	47	1	27	28
Ohio River:						
Cairo, Ill	5	14	19	1	1	2
Toronto, Ohio	5	23	28	0	1	1
Pend Oreille River:						
Albeni Falls Dam, Idaho	0	7	7	0	1	1
Platte River:						
Plattsmouth, Nebr	22	19	41	5	5	10
Potomac River:						
Washington, D.C	0	5	5	0	1	1
Red River, North:						
Grand Forks, N. Dak	4	36	40	0	2	2
Red River, South:						
Alexandria, La	16	11	27	5	2	7
Rio Grande:						
El Paso, Tex	2	23	25	3	5	8
Laredo, Tex	6	10	16	1	2	3
Sacramento River:						
Greens Landing, Calif	4	8	12	0	<1	<1
San Joaquin River:						
Vernalis, Calif	5	0	5	0	3	3
San Juan River:						
Shiprock, N. Mex	62	26	88	5	10	15
Savannah River:						
Port Wentworth, Ga	5	10	15	<1	0	<1
Snake River:						
Wawawai, Wash	2	6	8	0	3	3
South Platte River:						
Julesburg, Colo	14	57	71	3	32	35
Tennessee River:						
Lenoir City, Tenn	2	6	8	0	0	0
Chattanooga, Tenn	2	9	11	<1	0	<1
Bridgeport, Ala	3	9	12	1	0	1
Pickwick Landing, Tenn	1	8	9	<1	1	<2
Tombigbee River:						
Columbus, Miss	10	9	19	3	0	3
Wabash River:						
New Harmony, Ind	3	11	14	<1	1	<2
Yellowstone River:						
Sidney, Mont	2	14	16	1	6	7
Maximum	340	660	705	80	32	83
Minimum	0	0	4	0	0	0

Note: These data are preliminary; reanalysis of some samples may be made and additional analysis not completed at the time of the report may become available. For final data, one should consult the system's annual report.

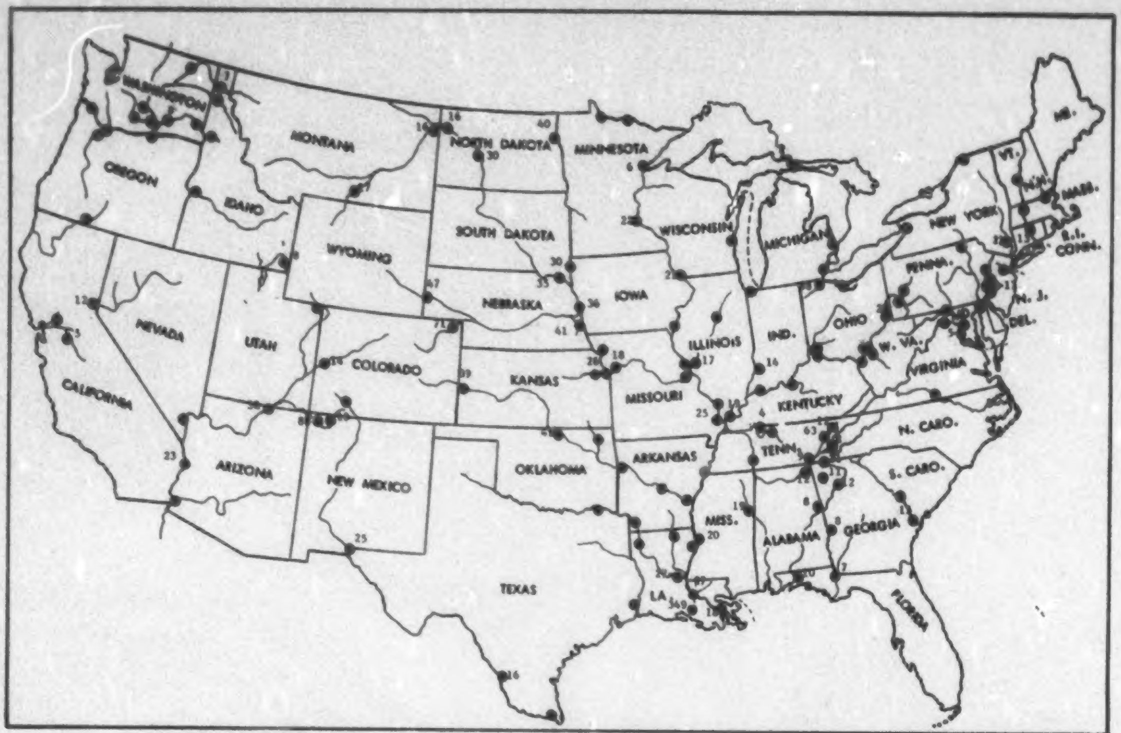
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FIGURE 1.—SAMPLING LOCATIONS AND ASSOCIATED TOTAL BETA ACTIVITY (pc/liter) IN SURFACE WATERS, NOVEMBER 1964

A geographical perspective of the radioactivity in surface water is obtained from the numbers printed near the stations as shown in figure 1 which gives the average total beta activity in suspended-plus-dissolved solids in raw water collected at each station. Gross radioactivity results for the years 1957-1962 have been summarized by Weaver *et al* (*9*).

Discussion

The radioactivity associated with dissolved solids provides a rough indication of the levels which could occur in treated water, since nearly all suspended matter is removed by the treatment process (*10*). The Public Health Service Drinking Water Standards state that in the absence of strontium-90 and alpha emitters,[1] a water supply is acceptable when the gross beta concentration does not exceed 1,000 pc/liter (*11*).

The monthly average dissolved beta activities were below 100 pc/liter at all but two stations. These results were found on the Columbia River: Pasco, Washington and Clatskanie, Oregon had values of 660 and 121 pc/liter respectively.

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[1] Absence is taken here to mean a negligibly small fraction of the specific limits of 3 pc/liter and 10 pc/liter for unidentified alpha emitters and strontium-90 respectively.

[2] Single free copies of this publication may be obtained from: Public Inquiries Branch, Public Health Service, U.S. Department of Health, Education, and Welfare, Washington, D. C. 20201.

Section IV—Other Data

THE DENTAL SURPAK PROGRAM AND RESULTS THROUGH DECEMBER 1963

James W. Miller[1]

One of the first tasks of the Public Health Service's Division of Radiological Health, when it was formed in 1958, was to develop plans for a nationwide comprehensive radiological health program to be conducted in cooperation with State health agencies, professional organizations representing the healing arts, and with other Federal agencies. Among the principal sources of ionizing radiation encompassed in these plans were X-ray machines of all types, nuclear reactors and their radioactive byproducts, high energy particle accelerators, concentrated forms of naturally-occurring radioactive materials, and fallout resulting from detonation of nuclear devices. The task was complicated by a critical shortage of individuals well trained in radiation control methods at all levels of government.

A large percentage of the manmade radiation exposure received by the U.S. population today is attributable to the use of X-ray machines by the health professions. Of the estimated 200,000 X-ray machines in this country, approximately 100,000 are owned and operated by dentists. The X-ray machines under the control of the dental profession expose about 185,000,000 dental films a year. While the possible contribution to somatic and genetic exposure arising from dental radiography is considerably less than that from medical sources (*1, 2*), a conservative assumption is that the somatic and genetic effects resulting from radiation insult have no threshold and that a direct linear relationship exists between dose and biological effect (*3*). Thus, in general, any exposure of an individual or a population group to ionizing radiation involves some risk, and the benefits resulting from such an exposure must be weighed against the risk involved. No matter how small the present radiation exposure is to the patient or to the occupationally-exposed person, if it can be reduced without adversely affecting the clinical results, every reasonable effort should be made to accomplish this reduction.

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Studies conducted in larger centers of population by interested parties and agencies following the 1956 report of the National Academy of Sciences (4) indicated that a large percentage of the dental X-ray machines in this country did not meet recommendations set forth by either the National Committee on Radiation Protection and Measurements (5) or the American Academy of Oral Roentgenology (6).

Initial X-ray control activity in many States started with radiation surveys of dental X-ray machines. Attention was given to dental X-ray machines, not because they were the greatest source of unnecessary population exposure, but for the following reasons:

1. There are fewer variables in dental equipment, thereby making them easier to inspect than X-ray machines in use by other health professions.
2. Dental X-ray equipment defects lend themselves to relatively simple detection, modification and/or correction.
3. A significant reduction in exposure could be accomplished from the correction of dental X-ray equipment.
4. The dental profession as a whole was extremely interested in and receptive to a program to correct equipment deficiencies.
5. Almost half of the X-ray machines in this country are used by dentists.
6. Due to the newness of the field, there was a lack of trained or knowledgeable personnel and a lack of experience in carrying out X-ray control programs.
7. Experience and information gained from dental X-ray control programs could be applied to more complex problems in the development of a comprehensive program dealing with all phases of radiological health.

With the limited number of people available and the large number of X-ray machines to check, office visits alone were impractical to identify defective equipment within a reasonable period of time. Some technique other than the office visit was needed to accomplish this. The Public Health Service's Division of Radiological Health devised the dental X-ray mail-order film step-wedge survey packet, commonly known as the "dental Surpak" (7).

Survey Method

The Surpak is a device that enables the practicing dentist to cooperate with his state health agency in determining whether his X-ray unit has characteristics which contribute to unnecessary radiation exposure.

This simplified procedure is useful primarily in assessing factors that affect X-ray exposures of dental patients rather than operators. Since factors reducing patient exposure can also reduce exposure of operating personnel, the procedure may also provide clues to the occupational doses of the dentist and his assistant. This method will assist materially in indicating the need for reducing unnecessary patient and occupational exposure, but will not completely remove the need for a physical inspection. Additionally, it can serve as an aid in surveying areas not readily reached by health department personnel, locating priority needs, and as a method of followup and evaluation after recommended improvements reportedly have been made.

The complete Surpak consists of three parts:

1. A mailing envelope. This envelope has the health agency's address imprinted in the upper left-hand corner.
2. A return-mail envelope. This envelope has the health agency's address imprinted in the center of the face of the envelope.
3. The Surpak itself in a sealed envelope. On the face of this envelope will be found a code number, general instructions, and spaces to be filled in by the dentist in reference to his particular X-ray machine(s). Inside is a slow industrial 8 x 10-inch X-ray film with lead backing, an aluminum step-wedge and a lead code number (See figure 1).

The general instructions direct the dentist to lay the film envelope face up on a flat horizontal surface with the pointer cone positioned perpendicularly to the Surpak so that the end of the cone touches the center of the circle on the envelope. The exposure is then made according to a printed schedule on the envelope, and returned in the envelope provided. The spaces to be filled in are labeled according to location (county and city), manufacturer, model number, tube housing serial number, console serial number, and data for the exposure (pointer cone used, kilovolt peak, tube current, exposure time, and date).

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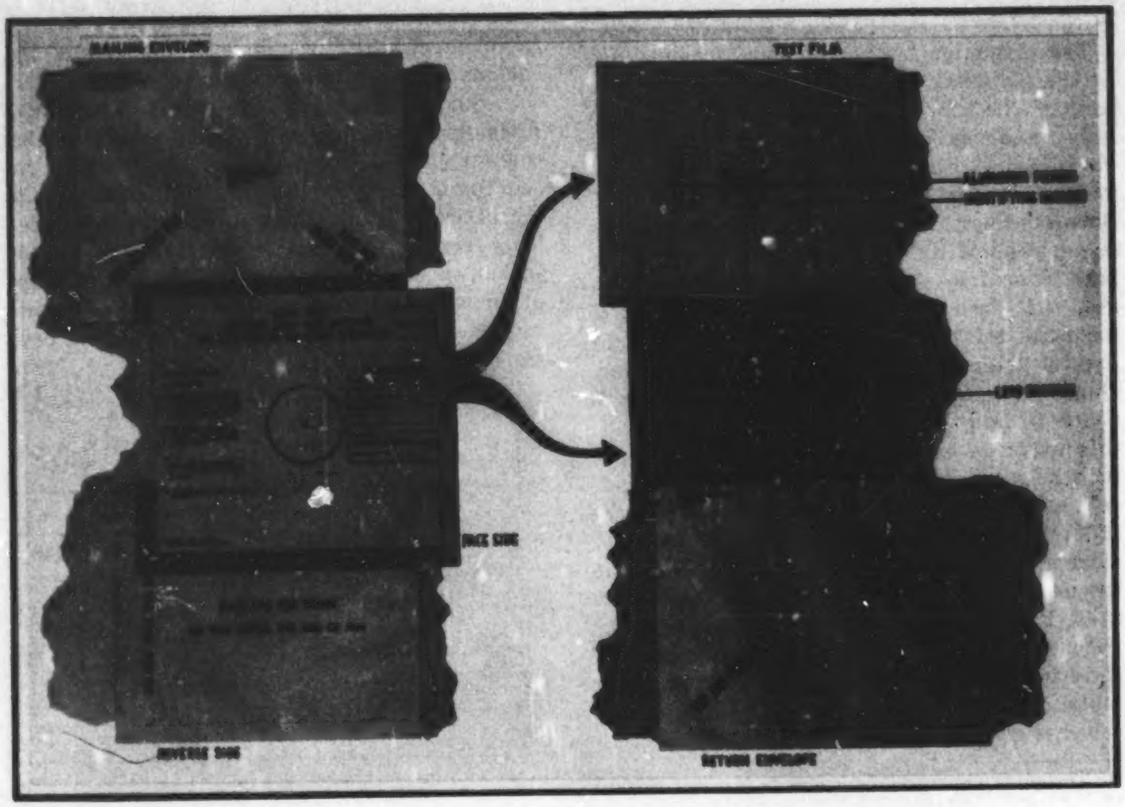

Figure 1.—THE DENTAL SURPAK

The name and address of the dentist does not appear on any Surpak. The health agency assigns a code number to each participating dentist and mails a complete Surpak to him. The participating dentist, in turn, fills in the blanks, exposes the Surpak as instructed, and returns it by mail to the health department (see figure 2). This takes just a few moments of his time. The exposed Surpaks are then returned by the health agency to the Public Health Service Radiological Health Laboratory, Rockville, Maryland, for controlled processing and interpretation (*8*).

Specific information provided by a properly exposed Surpak for a specific X-ray machine includes the size of the beam at the end of the pointer cone, the approximate roentgen output in mr/mas, total filtration (inherent and added), beam symmetry, and leakage radiation in the direction of a patient's face.

Information obtained from the processed film is transferred to data processing punch cards from which a list of findings is prepared, and returned to the local health departments. Each health department in turn notifies the participating dentists of the results obtained and if needed, makes recommendations as to corrective procedures required to bring their X-ray machines up to recommended standards if needed.

Surpak Survey Results

A total of 58,000 Surpaks had been distributed to 39 States as of June 30, 1964. Of the States that have used the Surpak in their programs, 27 have completed their initial survey in the sense that 65 to 95 percent of the dentists cooperated on a voluntary basis. The mode is 80 percent voluntary cooperation on a national basis. Results from 40,810 Surpaks returned by December 30, 1963 provided the following information.

Collimation

The maximum beam diameter recommended by the National Committee on Radiation Protection[2] (NCRP) in National Bureau of Standards Handbook 76 is 3 inches at the tip of the cone (*5*). A value of 2.75 inches is recommended by the American Academy of Oral Roentgenology (AAOR). The present recommendations of the Public Health Service combine these two standards and currently suggest that "the beam diameter should be 2.75 inches at the tip of the cone and shall not be greater than 3 inches." The majority of machines not meeting present standards had beams of less than 4 inches in diameter. While this may not seem excessive, reducing a 3.5 inch beam to 2.75 inches results in a 38 percent reduction in area of exposure. While the reduction in area exposed is of interest, of more import is the reduction of doses to certain tissues such as the thyroid and the lens of the eye. Reduction of scatter radiation to the tissues would also result from the reduction of the size of the X-ray beam. Five percent of the units checked had beams with diameters of 4 inches or more.

In order to assess the progress in dental radiological health, the data were evaluated by calendar year, starting with 1960, the first year the Surpak was used in State programs. Although results from different parts of the country varied, a trend could be detected in the increase in the number of dental X-ray machines meeting present recommendations. This trend is apparent in table 1. Using three inches as the maximum beam size, the number of machines meeting this requirement increased from 45.2 percent in 1960 to 63.6 percent in 1963.

TABLE 1.—BEAM DIAMETER MEASUREMENTS BY SURPAK, IN PERCENT, BY CALENDAR YEAR

Diameter (inches)	Percent by years			
	1960	1961	1962	1963
Not stated			0.02	
Unknown	1.2	1.8	0.8	1.0
≦2.75	32.7	43.0	47.2	45.4
2.76–3.00	12.5	13.4	12.7	18.2
3.01–3.99	48.1	36.6	34.0	30.6
4.00–4.99	3.3	2.7	2.5	2.6
5.00–5.99	1.6	1.5	1.6	1.3
6.00–6.99	0.5	0.5	0.5	0.5
7.00+	0.06	0.4	0.4	0.4
Total	100.0	99.9	99.8	100.0

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[2] The name was recently changed to *National Council on Radiation Protection and Measurements.*

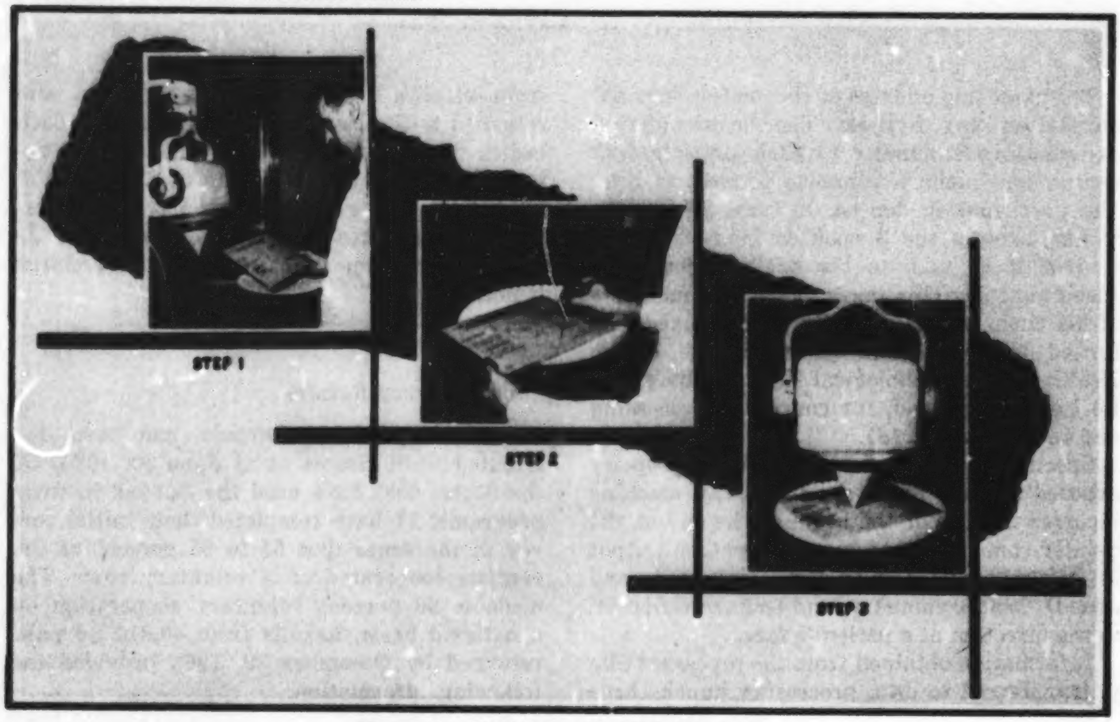

FIGURE 2.—THE USE OF THE SURPAK

Filtration

The recommendations for total filtration of the primary beam also differs between the NCRP and AAOR. A total of 2.0 mm of aluminum equivalent filtration is recommended by the AAOR, regardless of kilovoltage used, while the recommendations of the NCRP are 1.5 mm of aluminum equivalent for equipment operating up to and including 70 kvp and 2.5 mm total for those operating above 70 kvp. Even though the accuracy of the filtration determination by the Surpak method is subject to some inherent errors, sufficient information is obtained to make a reasonable estimate in most cases. The unknown values in the filtration tables are the result of over- or underexposure of the Surpak films, making it impossible to estimate.

Using 1.5 mm of aluminum as the minimum amount of filtration required for dental X-ray machines regardless of kvp, it can be noted (table 2) that during the last four years there has been a 20 percent increase in the number of machines that meet this minimum standard.

TABLE 2.—SURPAK RESULTS: TOTAL FILTRATION IN PERCENT, BY CALENDAR YEAR

Degree of filtration	Percent of surveys, by years			
	1960	1961	1962	1963
Unknown	5.9	15.6	14.9	10.8
<1.5 mm	51.9	38.2	29.7	29.0
≥1.5	42.2	46.2	55.4	60.2
Total	100.0	100.0	100.0	100.0
Total number of surveys *	1,137	12,243	13,873	7,557

* Does not include resurveys.

Collimation and filtration

Usually the number of machines which meet the recommendations for both filtration and collimation are reported in the literature. This information is presented in table 3. The percentage of machines needing correction when 2 safety features are used is substantially higher than when only one is used. In general, 70 percent of the dental X-ray machines checked for the first time today by the Surpak method would require correction in order to meet present requirements for both filtration and collimation when initially inspected. This represents an improvement over the 1960 findings, which showed that 82.5 percent of the machines required these corrections.

TABLE 3.—DENTAL SURPAK FILTRATION AND COLLIMATION RESULTS

Collimation (in inches)	Total filtration (mm aluminum equivalent)	Percentages observed, by years			
		1960	1961	1962	1963
≤3.00"	Unknown	5.8	16.0	15.0	10.8
	<1.5	13.9	14.1	11.0	10.8
	≤1.5	17.5	23.6	30.2	30.5
>3.00"	<1.5	37.9	23.8	18.5	18.1
	≥1.5	24.7	22.2	25.0	29.5
	Total	99.8	99.7	99.7	99.7

Roentgen output

The output of the useful beam in milliroentgens per milliampere second (mr/mas) was determined from net densities read from the exposed film converted to relative exposure in roentgens using appropriate graphs and information recorded on the face of the Surpak envelope by the dentist. As can be seen from table 4, 66.1 percent of machines have an output of under 2 roentgens per second when operated at 10 ma (200 mr/mas). These findings compare favorably with results obtained from other inspections where the output was measured using more refined methods, such as a Victoreen Condenser-r-meter.

TABLE 4.—ROENTGEN OUTPUT DETERMINED BY SURPAK

Roentgen output (mr/mas)	Number	Percent
Unknown	9,753	23.9
000–099	10,770	26.4
100–199	16,182	39.7
200–299	3,505	8.6
300–399	350	0.9
400–499	77	0.2
>500	83	0.2
Total	40,810	100.0

Primary leakage

For purposes of the Surpak, this is defined as primary radiation discernable on the 8 x 10-inch film that is not limited to the area of the useful beam at the tip of the pointer cone. This may in some cases be due to poorly-fitting or loose collimators. Table 5 shows the number and percentage of machines having primary leakage. While the percentage of machines having leakage in the anterior direction is small, this source of unnecessary radiation could not be readily detected by other survey methods.

TABLE 5.—ANTERIOR PRIMARY LEAKAGE DETERMINED BY SURPAK

Primary leakage	Number	Percent
Unknown	628	1.5
Yes	1,241	3.0
No	38,941	95.4
Total	40,810	99.9

Corrections

The Surpak has proved to be a very valuable tool in identifying equipment in need of correction. Faced with the shortage of trained personnel to follow up on defective units, health agencies wanted to know how they could correct these machines. Experience from limited studies in which recommendations were made to bring X-ray machines up to standards showed that upon follow-up surveys, less than 30 percent of the initially defective units had been corrected. Many reasons for this noncompliance with recommended standards were identified, but the most fundamental reason was that the necessary filters and collimators were not readily available. It was felt that if these materials were provided and the dentist made aware of why and how to install the corrective devices, he would cooperate. On this premise the Public Health Service produced suitable filters and collimators and made them available to dentists through State health departments.

Five manufacturers of dental X-ray machines were identified as the source of more than 92 percent of all units in use in this country. Enough filters and collimators to correct 70,000 of these five most common X-ray machines have been distributed to health agencies by the Public Health Service. In addition to providing filters and collimators, a booklet was also developed by the Public Health Service entitled "Radiation Protection for Dentist and Patient" (Public Health Service Publication No. 885). Its contents explain simply the "Why" and "How" of radiological health in the dental office, and the methods of equipment correction. To date, 95,000 of these booklets have been distributed. With these tools, health agencies have additional resources to correct the major machine deficiencies by mail.

By 1962, several States had progressed to a point in their program where the original Surpak data had been evaluated and recommendations for correction had been sent to the dentists. In most cases, the State health department had sent the individual practitioner the lead collimators and aluminum filters necessary to bring most X-ray machines into compliance with established standards for filtration and collimation. After a period of time, a follow-up Surpak was sent to the dentist to determine whether the lead collimator and aluminum filters were being used. The results of these resurveys varied according to the effort that the health departments and the dental societies made to obtain compliance, but a persistent gain in the number meeting recommended standards is indicated.

During 1962 and 1963 as a result of this mail order survey and follow-up program, 80 percent of the dental X-ray machines found not meeting recommended standards for beam diameter at the time of the original survey were brought into compliance.

Summary and conclusions

The "Dental Surpak" was devised by the Division of Radiological Health as a method of identifying dental X-ray units which contribute to unnecessary radiation exposure.

A total of 58,000 Surpaks had been distributed to 39 States as of June 30, 1964. Of the States that have used the Surpak, 27 have completed their initial survey. Results from over 40,000 of these surveys indicate that 60 to 80 percent of the units inspected for the first time would not meet recommended standards for filtration and collimation. During 1962 and 1963, an average of 80 percent compliance in X-ray machines originally found to be below standards was obtained by this dental mail-order survey and correction method.

The "Dental Surpak" has proven to be a valuable public health tool. The correction of filtration and collimation defects identified through its use has resulted in a substantial decrease in the dental contribution to population radiation exposure.

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(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, report no. 1, Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 13, 1960), price 20 cents.

(*4*) NATIONAL ACADEMY OF SCIENCES—NATIONAL RESEARCH COUNCIL. The biological effects of atomic radiation, summary reports. Washington, D.C. (1956).

(*5*) NATIONAL COMMITTEE ON RADIATION PROTECTION AND MEASUREMENTS. Medical X-ray protection up to three million volts. National Bureau of Standards Handbook 76, Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (February 9, 1961), price 35 cents.

(*6*) RICHARDS, A. G. *et al.* X-ray protection in the dental office. J Amer Dent Ass 56:514–521 (April 1958).

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(*8*) WINKLER, K. A film method for determining peak kilovoltage, total filtration and roentgen output of an X-ray machine (in preparation).

RADIONUCLIDES IN ALASKAN CARIBOU AND REINDEER, 1963–1964

Division of Radiological Health, Public Health Service

A new phase in assessing the radionuclide intake of Alaskan residents began in 1963, when caribou and reindeer sampling and analysis were undertaken by the Alaskan Departments of Health and Welfare and of Fish and Game, and the Public Health Service, under a cooperative agreement between these agencies. The basis for this joint activity stemmed from a more limited sampling effort conducted by these groups in 1962.

Through the second quarter of 1964, the sampling was confined to the three principal caribou (*Rangifer caribou*) herds and one privately owned reindeer (*Rangifer tarandus*) herd. This program was expanded when, beginning in September 1964, the sampling of additional privately-owned reindeer herds was begun through the assistance of the Fish and Wildlife Service and Bureau of Indian Affairs, Department of Interior.

Figure 1 shows the locations and approximate number of animals in the caribou and reindeer herds sampled. In general, the reindeer herds are located on or near the Seward peninsula and on two islands off the western coast of Alaska.

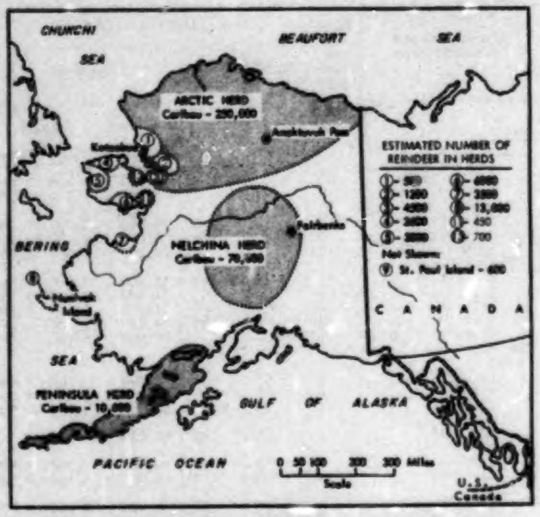
CHUKCHI SEA
BEAUFORT SEA
ARCTIC HERD
Caribou - 250,000
Anaktuvuk Pass
Kotzebue
NELCHINA HERD
Caribou - 70,000
Fairbanks
BERING SEA
Nunivak Island
PENINSULA HERD
Caribou - 10,000
GULF OF ALASKA
PACIFIC OCEAN
0 50 100 200 300 Miles
Scale
ESTIMATED NUMBER OF REINDEER IN HERDS
① - 500
② - 1200
③ - 4500
④ - 2600
⑤ - 3000
⑥ - 6000
⑦ - 3800
⑧ - 13,000
⑨ - 450
⑩ - 700
Not Shown:
⑨ St. Paul Island - 600
CANADA
U.S.
Canada

FIGURE 1.—NUMBERS OF CARIBOU AND REINDEER IN HERDS SAMPLED, 1964

Samples of muscle, rumen contents, and bone from 5 animals (two or three years old) in each herd sampled are collected in approximately April, July, September, and December of each year. The muscle samples, weighing

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about two pounds each, are frozen for shipment. The bone samples consist of the hock from each animal. The rumen content samples, weighing about two pounds wet, are dried for shipment. All samples are shipped in dry ice to the Public Health Service Southwestern Radiological Health Laboratory in Les Vegas, Nevada, for analysis.

The analytical procedure includes gamma scintillation spectroscopy for cesium-137 and other gamma emitters. Strontium-89 and strontium-90 are determined by chemical separation followed by beta counting. Analysis for stable calcium is done by a flame-photometric method.

Strontium-89, strontium-90, and cesium-137 results are presented in tables 1-3 for caribou and reindeer muscle, rumen contents, and bone, respectively. Figures 2 and 3 depict levels of strontium-90 and cesium-137, respectively, in muscle and rumen content of the three caribou herds sampled.

TABLE 1.—AVERAGE RADIONUCLIDE VALUES IN CARIBOU AND REINDEER MUSCLE

Specimens and sampling dates	Number of samples	pc/kg wet weight			
		Strontium-89	Strontium-90	Cesium-137	
				Average	Range
Caribou					
Arctic herd 12/21/63	3	* <5	* 17	4,880	3,750- 5,680
4/27-5/19/64	5	* <5	* 400	13,800	5,000-21,000
8/20-8/29/64	5	* <5	* 40	700	400- 1,000
12/7-12/15/64	5			3,900	1,400- 5,300
Nelchina herd					
11/24-11/25/63	5	* 5	* 33	21,800	16,900-26,400
4/24-4/26/64	5	* 10	* 54	5,560	2,600-10,000
12/8-12/9/64	5			14,000	7,900-22,000
Peninsula herd					
12/12-12/19/63	5	* 10	* 84	44,800	33,600-57,700
4/9-4/15/64	5	* <5	* 14	14,800	12,000-18,000
7/11/64	4	* <5	* 5	1,680	1,400- 2,000
9/26-10/1/64	5	* <5	* 11	4,630	1,200- 9,250
12/14-12/17/64	5			18,000	8,700-31,000
Reindeer					
R-1					
12/27/63	4	* <5	* 31	7,190	6,730- 7,540
9/7/64	5	* <5	* 74	3,340	2,300- 4,900
12/15/64	4	* <5	* 268	23,000	13,000-30,000
R-2					
12/15/64	1	<5	578	34,000	
R-3					
9/26/64	2	* <5	* 68	19,600	13,400-25,800
12/15/64	4	* <5	* 64	14,000	5,100-32,000
R-4					
9/26/64	3	* <5	* 38	8,490	7,660-10,000
12/15/64	5	* <5	* 68	12,000	4,900-29,000
R-5					
12/15/64	5	* <5	* 66	35,000	25,000-47,000
R-6					
12/15/64	5	* <5	* 96	19,000	11,000-30,000
R-7					
12/24/64	5			30,000	14,000-37,000
R-8					
9/18/64	5	* <5	* 75	7,080	5,000- 9,200
12/24/64	5			25,000	9,800-35,000
R-9					
9/24/64	4	* <5	* 10	4,880	2,080- 7,530
11/19-11/20/64	5			13,000	4,400-16,000
R-13					
12/15/64	5	* <5	* 127	28,000	23,000-34,000

* Indicates samples composited before analysis.

TABLE 2.—AVERAGE RADIONUCLIDE VALUES IN ALASKAN CARIBOU AND REINDEER RUMEN CONTENTS

Specimens and sampling dates	Number of samples	pc/kg wet weight			
		Strontium-89	Strontium-90	Cesium-137	
				Average	Range
Caribou					
Artic herd					
12/21/63	3	* 600	* 4,440	4,430	3,980- 4,770
4/27-5/19/64	5	* <5	* 1,680	4,440	4,000- 6,000
8/20-8/29/64	5	* 40	* 1,730	1,470	970- 2,200
12/7-12/15/64	5			4,100	1,800- 6,300
Nelchina herd					
11/24-11/26/63	5	* 400	* 5,150	4,880	1,100- 7,430
4/24-4/26/64	5	* <5	* 1,550	8,400	2,500-12,000
12/8-12/9/64	5			7,200	4,300- 9,000
Peninsula herd					
12/12-12/19/63	5	* 1,550	* 5,700	7,920	4,020-12,300
4/9-4/15/64	5	* <5	* 1,370	1,840	1,400- 2,600
7/11/64	5	* <5	* 311	690	630- 740
9/26-10/1/64	5	* <5	* 825	5,880	1,500-13,300
12/14-12/17/64	5			4,900	2,200- 8,000
Reindeer					
R-1					
12/27/63	4	* <5	* 5,600	4,650	3,700- 5,300
12/15/64	5			5,400	2,300- 7,900
R-2					
12/15/64	1			6,900	
R-3					
9/26/64	1	<5	315	10,900	
12/15/64	3	* <5	* 5,810	5,500	5,200- 5,700
R-4					
9/25/64	1	<5	1,710	5,770	
12/15/64	5	* <5	* 2,440	1,900	1,100- 2,700
R-5					
9/18/64	5	* 5	* 3,000	3,600	2,500- 4,510
12/24/64	5			5,400	1,100-10,000
R-9					
9/24/64	3	* <5	* 720	1,310	660- 1,900
11/19-11/20/64	5			4,400	1,700- 8,300
R-11					
12/15/64	5			4,000	2,400- 7,400

* Indicates samples composited before analysis.

The muscle data are of prime interest since muscle, in contrast to rumen or bone, is an important constituent of the diet for many Alaskan residents. A tendency toward increased cesium-137 values in caribou muscle during and immediately following the winter diet and lower values during and immediately following the summer diet can be seen. The reindeer muscle data are too few to permit similar observations.

These data represent one aspect of the Division's surveillance activities in Alaska. An accompanying program for assessing radiation levels in the human population, consisting of bone sampling and whole body counting, is currently in progress.

TABLE 3.—AVERAGE RADIONUCLIDE VALUES IN ALASKAN CARIBOU AND REINDEER BONE

Specimens and sampling dates	Number of samples	pc/g ash		pc/kg wet	
		Strontium-89	Strontium-90	Cesium-137	
				Average	Range
Caribou					
Artic herd					
12/21/63	3	[a]90	[a]225	170	120– 210
4/27–5/19/64	5	[a]<5	[a]143	[b]—	—
8/20–8/29/64		<5	137	—	—
Nelchina herd					
11/24–11/25/63	5	[a]<5	[a]117	920	530– 1,940
4/24–4/25/64	5	[a]<5	[a]143	—	—
Peninsula herd					
12/12–12/19/63	5	[a]<5	[a]118	3,930	3,240– 4,780
4/9–4/15/64	5	[a]<5	[a]116	—	—
7/11/64	4	[a]<5	[a]115	—	—
9/26–10/1/64	4	[a]<5	[a]90	—	—
Reindeer					
R-1					
12/27/63	4	[a]25	[a]64	830	750– 920
9/7/64	5	[a]<5	[a]96	2,240	1,300–22,700
12/15/64	5	[a]<5	[a]116	—	—
R-2					
12/15/64	1	<5	105	—	—
R-3					
9/26/64	2	[a]<5	[a]184	3,670	1,880– 5,460
12/15/64	2	[a]7	[a]175	—	—
R-4					
9/25/64	3	[a]<5	[a]115	2,050	1,080– 2,880
12/15/64	2	[a]<5	[a]135	—	—
R-5					
12/15/64	5	[a]<5	[a]185	—	—
R-6					
12/15/64	1	<5	197	—	—
R-8					
9/18/64	5			1,420	1,080– 1,790
12/24/64	5			2,000	360– 3,700
R-9					
9/24/64	4	[a]<5	[a]64	460	340– 610
11/19–11/20/64	5	[a]<5	[a]214	750	400– 880
R-11					
12/15/64	1	<5	214	—	—
R-13					
12/15/64	1	<5	177	—	—

[a] Samples composited before analysis.
[b] Dash indicates no analysis.

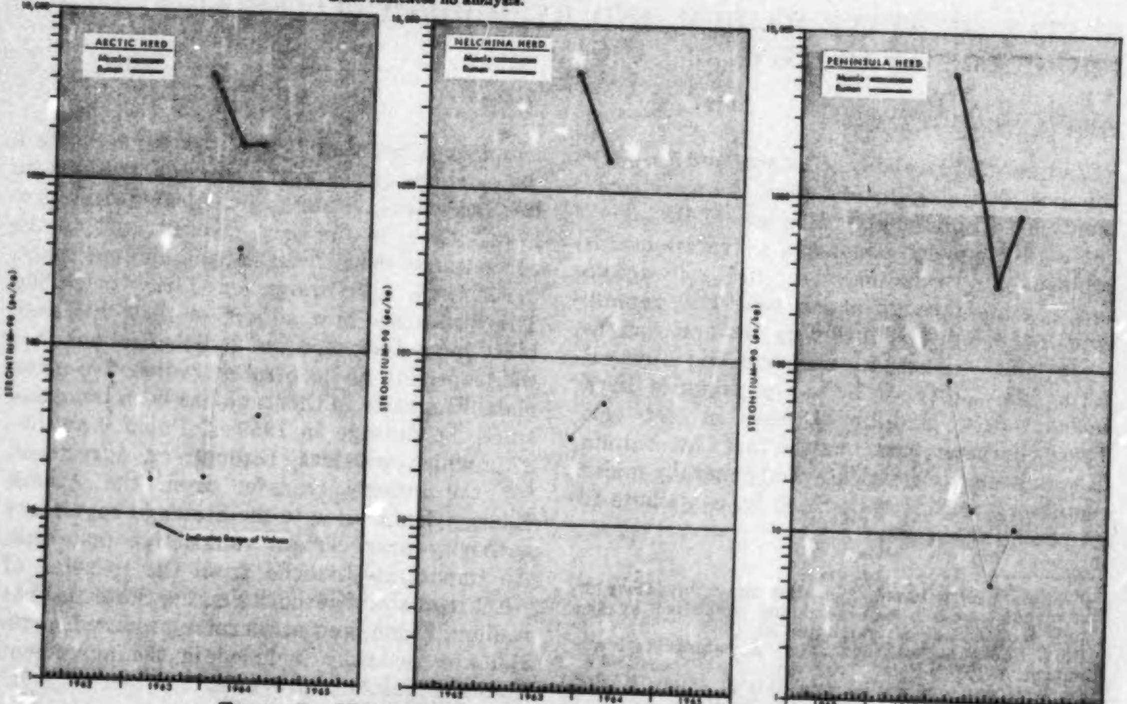

FIGURE 2.—STRONTIUM-90 IN ALASKAN CARIBOU MUSCLE AND RUMEN CONTENTS

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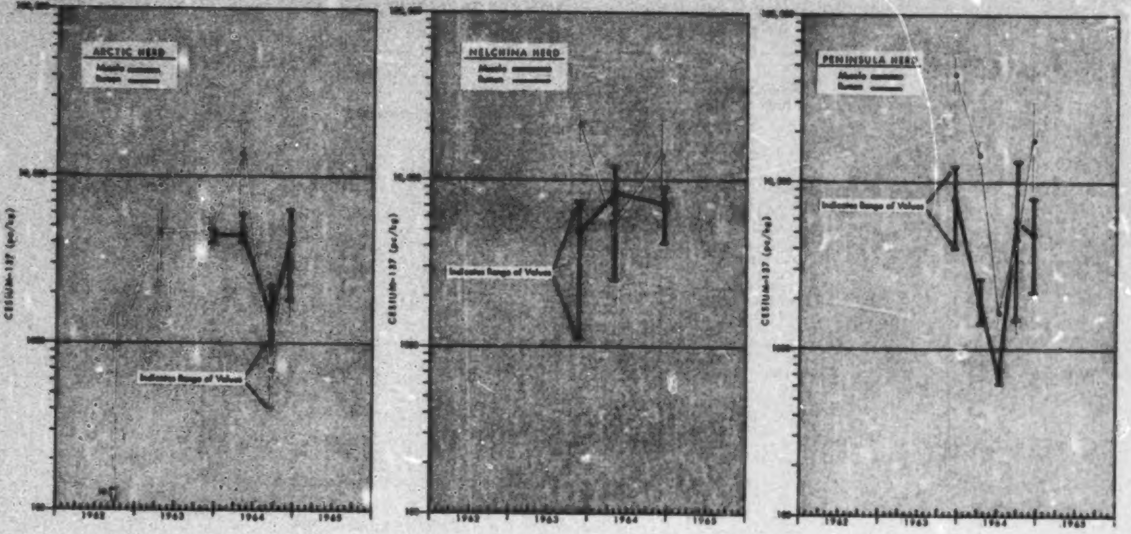

FIGURE 3.—CESIUM-137 IN ALASKAN CARIBOU MUSCLE AND RUMEN CONTENTS

STATUS OF STATE RADIUM AND BYPRODUCT MATERIAL PROGRAMS AS OF JUNE 30, 1964[1]

John G. Bailey[2]

Radium–226 has had the longest and possibly the most dramatic history of all the more commonly used radionuclides. Certain of its inherent characteristics make it a potential health problem—its radiotoxicity; its radioactive series decay through alpha, beta, and gamma emitting daughters, including its first daughter product, radon; its chemical and physical form; its ability to build up pressure in a sealed source; and its decrease in cost (*1*). These characteristics, and the fact that radium has not been systematically and generally under regulatory control until recently, contribute to its potential hazards.

Since medical and dental X-rays contribute a major share of the total radiation exposure to the individual, State radiological health programs have, in the past, concentrated on the correction of deficiencies in techniques of usage, installation, and design of X-ray machines. The States are now adding to their responsibility in another aspect of radiological health—the inspection and control of radioactive materials. Emphasis in this area has been increased since the passage in 1959 of Public Law 86–373, which provides, through an agreement, for the orderly transfer from the Atomic Energy Commission to the States of regulatory authority over certain radioactive materials. An important dividend from the transfer of AEC regulatory authority to the States is that radium, radon, and accelerator-produced material are generally included in the agreement States' regulatory program.

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[1] This article is based upon data in an inventory of State radiological health programs conducted by the Public Health Service as of June 30, 1964.

[2] Mr. Bailey is Assistant Chief, Assistance to State Radioactive Materials Program, State Assistance Branch, Division of Radiological Health, Public Health Service, DHEW, Washington, D.C. 20201.

Commonly used radioactive materials fall into two distinct categories: byproduct radionuclides,[3] which have had strict government licensing by either the AEC or the agreement States;[4] and those radionuclides, radium, radon, and accelerator-produced material, which until recently were under virtually no regulatory control.

As of June 30, 1964, (see table 1), six States had assumed regulatory control over byproduct materials from the AEC. An additional 28 States are working toward an agreement before 1970.[5] Of approximately 8,200 organizations and individuals in the United States that possessed byproduct material licenses (licensees), 2,260 (28 percent) were licensed by the six agreement States (*2*). These States contain 27 percent of the Nation's population.

In addition to those States becoming responsible for regulatory control of byproduct material, an increasing number of States are developing programs for radium and other nonagreement materials. Twenty-six States, as shown in figure 1, had comprehensive programs for the control of radium. These comprehensive programs include registration or licensing of radium as well as State inspections or surveys of radium installations. An additional 12 States identified the user of radium through a registration or licensing program but had not yet developed radium inspection programs. Four other States had only limited programs of radium installation inspections. Of the 30 States with inspection programs, 15 had inspected all known radium installations.

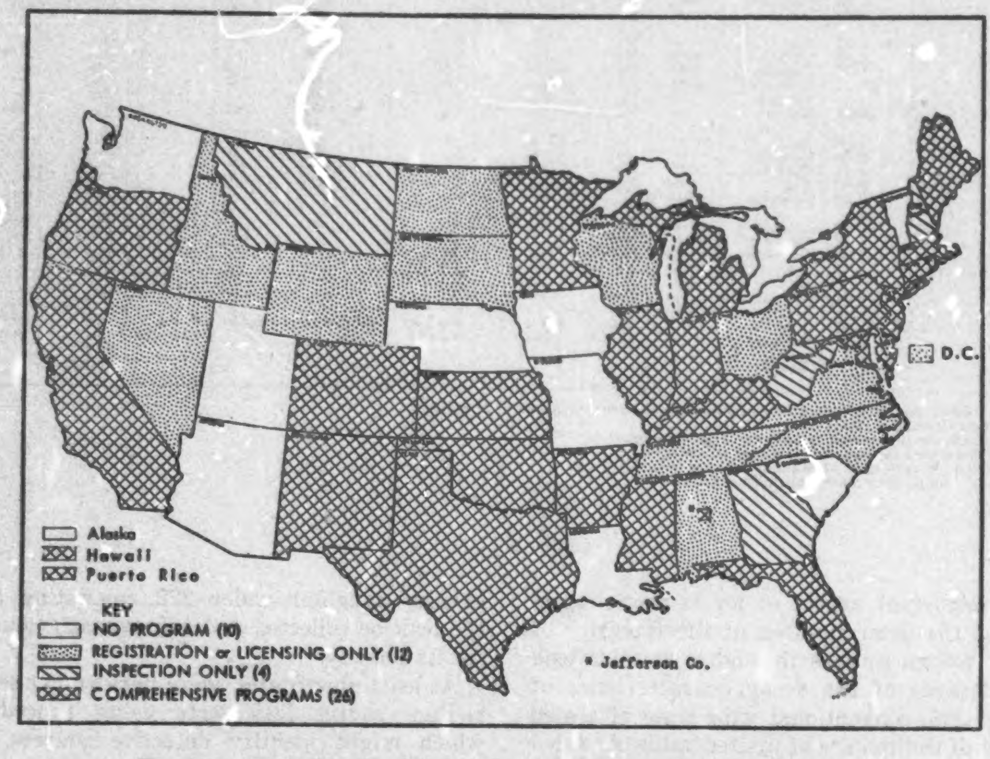

FIGURE 1.—STATUS OF STATE RADIUM PROGRAMS—JUNE 30, 1964

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[3] Those radionuclides which are ". . . yielded in or made radioactive by exposure to the radiation incident to the process of producing or utilizing special nuclear material." (Code of Federal Regulations, Title 10, Chapter 1, Part 30, Section 30.4b). For this discussion, source and special nuclear material are not included.

[4] Agreement State means ". . . any State with which the Commission has entered into an effective agreement under subsection 274.(b) of the Atomic Energy Act of 1954, as amended." (Code of Federal Regulations, Title 10, Chapter 1, Part 30, Section 30.4u).

[5] As of February 1, 1965, three additional States have assumed regulatory control over byproduct material from the AEC.

TABLE 1.—STATUS OF STATE RADIUM CONTROL PROGRAMS[a] AS OF JUNE 30, 1964

State	Population (millions) 1960 Census	AEC agreement		Radium		Radium		Radium installations	Alpha survey instruments	States doing:	
		Status	Year planned	Licensing	Registration	Inspection	Percent complete			Leak test [d]	Wipe test
Ala.	3.27	Consider	1966	No	Yes	[b] Yes	—	—	5	[b] Yes	—
Alaska	0.23	No	[c] —	No	No	No	—	—	1	No	—
Ariz.	1.30	Consider	—	No	No	No	—	—	0	No	—
Ark.	1.79	Yes	—	Yes	No	Yes	100	33	0	No	Yes
Calif.	15.72	Yes	—	Yes	No	Yes	60	310	8	[e] No	—
Colo.	1.75	Consider	1966	No	Yes	Yes	—	—	0	No	Yes
Conn.	2.54	Consider	1966	No	Yes	Yes	100	110	1	No	Yes
Del.	0.45	No	—	[f] Yes	No	No	—	—	0	No	—
D. C.	0.76	Consider	1967	No	Yes	No	—	—	4	No	—
Fla.	4.95	Consider	1964	No	Yes	Yes	—	—	3	No	Yes
Ga.	3.94	No	—	No	No	Yes	30	50	8	Yes	—
Hawaii	0.63	Consider	—	No	Yes	Yes	100	40	1	—	—
Idaho	0.67	No	—	No	Yes	No	—	—	1	No	Yes
Ill.	10.08	Consider	1966	No	Yes	Yes	100	150	3	Yes	—
Ind.	4.66	Consider	1965	No	Yes	Yes	100	115	2	No	Yes
Iowa	2.76	No	—	No	No	No	—	—	2	No	—
Kans.	2.18	Consider	1965	No	Yes	Yes	100	72	3	—	—
Ky.	3.04	Yes	—	No	Yes	Yes	100	51	1	Yes	—
La.	3.26	Consider	1966	No	No	No	—	—	1	No	—
Maine	0.97	Consider	—	No	Yes	Yes	83	18	0	No	Yes
Md.	3.10	Consider	1966	No	Yes	Yes	—	—	1	No	Yes
Mass.	5.15	No	—	No	Yes	Yes	—	150	3	—	—
Mich.	7.82	No	—	No	Yes	Yes	—	—	3	No	Yes
Minn.	3.41	No	—	No	Yes	Yes	25	64	2	No	Yes
Miss.	2.18	Yes	—	Yes	No	Yes	100	57	1	No	Yes
Mo.	4.31	No	—	No	No	No	—	—	0	No	—
Mont.	0.67	Consider	1969	No	No	Yes	80	15	0	Yes	Yes
Nebr.	1.41	Consider	1966	No	No	No	—	—	1	Yes	Yes
Nev.	0.28	No	—	No	Yes	No	—	8	1	—	—
N. H.	0.61	Consider	1965	No	No	Yes	100	—	4	No	Yes
N. J.	6.07	No	—	No	Yes	Yes	100	100	2	[e] No	—
N. Mex.	0.95	No	—	No	Yes	Yes	100	5	3	Yes	Yes
N. Y.	16.78	Yes	—	No	Yes	Yes	100	260	Many	[e] No	Yes
N. C.	4.56	Consider	1964	No	Yes	No	—	49	6	No	—
N. Dak.	0.63	No	—	No	Yes	No	—	20	1	No	—
Ohio	9.71	No	—	No	Yes	No	—	255	1	No	—
Okla.	2.33	Consider	1966	No	Yes	Yes	—	67	1	No	Yes
Ore.	1.77	Consider	1965	No	Yes	Yes	—	12	1	Yes	—
Pa.	11.32	Consider	1965	No	Yes	Yes	70	285	9	[e] No	—
P. R.		Consider	—	No	Yes	Yes	100	7	1	Yes	—
R. I.	0.86	No	—	No	Yes	Yes	100	60	1	No	Yes
S. C.	2.38	No	—	No	No	No	—	—	1	No	—
S. Dak.	0.68	Consider	—	No	Yes	No	—	14	1	No	—
Tenn.	3.57	Consider	1965	No	Yes	No	—	63	1	No	—
Tex.	9.60	Yes	—	Yes	No	Yes	100	120	2	[e] No	—
Utah	0.89	Consider	1969	No	No	No	—	—	1	No	—
Vt.	0.39	Consider	—	No	No	No	—	—	0	—	—
Va.	3.97	Consider	—	No	Yes	No	—	55	0	No	—
Wash.	2.85	Consider	—	No	No	No	—	—	1	No	—
W. Va.	1.[illegible]	No	—	No	No	Yes	—	—	1	No	—
Wis.	3.95	No	—	No	Yes	No	—	67	0	—	—
Wyo.	0.33	Consider	—	No	Yes	No	—	—	2	No	—
Totals	179.47	Yes = 6 Consider = 28 No = 18		Yes = 5 No = 47	Yes = 33 No = 19	Yes = 30 No = 22	100% = 15 States	2,810	States with = 42	9 by State 5 by owners	18 by State

[a] Total radium programs (inspection+licensing/registration) conducted in 26 States.
[b] Jefferson County, Alabama, only.
[c] Dash indicates information not known or not determined.
[d] Only those tests capable of determining radon leaking.
[e] Leak test not performed by State, required of owner.
[f] Permit required from State Health Department.

An important aspect of an inspection program is the determination of the integrity of sealed radium sources through a suitable leak test. Because of the decay characteristics of radium–226, conventional wipe tests of sealed sources of radium are of limited value. A sealed radium source leak test requires that the gaseous daughter, radon–222, emanating from the leak be collected and subsequently counted for its activity.

At least nine States, were performing sealed radium source leak tests using procedures which might identify defective sources. An additional five States require the radium source owner to perform leak tests or have them performed by commercial firms. At least 18 States perform wipe tests of either the radium source or of the storage area to determine removable contamination. Forty-two States were equipped with at least one survey meter suitable for determining the presence of alpha contamination.

From data supplied by 30 States, it is calculated that there are 20.9 radium installations per million population. Extrapolation of this figure gives a total of about 3,800 installations or individuals using radium in the United States.[6] This is a group equivalent in number to about 46 percent of the byproduct material licensees. As a check on the validity of this population extrapolated figure, the average ratio of radium installations to byproduct licensees was calculated to be 0.43 for those States supplying data. Using this ratio and the number of byproduct licensees, it is calculated that about 3,500 radium installations exist in the United States. The actual number of radium installations is probably greater than 3,800 because these estimates were extrapolated from only the known installations in those States with data. It should be noted that the radium installations and byproduct licensees are not mutually exclusive. In many of the facilities, the radium user will also process byproduct material.

The increase in State radioactive material programs from 16 States requiring licensing or registration of radium in fiscal year 1963 to 38 States in fiscal year 1964 is an encouraging step toward a nationwide program for radium control.

REFERENCES

(*1*) Villforth, John C. Problems in radium control. Public Health Rep. 79:337–341, April 1964.

(*2*) Data obtained from "Location and type of licensees", USAEC, June 30, 1964 (mimeo).

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[6] Earlier estimates (*1*) of 4,500 installations were based on more limited information collected in 1962.

ENVIRONMENTAL LEVELS OF RADIOACTIVITY AT ATOMIC ENERGY COMMISSION INSTALLATIONS

Atomic Energy Commission contractors who handle or produce radioactive materials are required to report periodically to the Commission on the environmental levels of radioactivity in the vicinity of major installations. These reports include data from routine monitoring programs where operations are of such a nature that plant perimeter surveys are required.

Selected summaries of the environmental radioactivity reports for 23 AEC installations are published regularly in *Radiological Health Data*. Summaries appearing in this issue cover the monitoring programs during the first half of 1964 at the following installations: Lawrence Radiation Laboratory and Mound Laboratory.

Releases of radioactive materials from these installations for the periods covered in the reports below are governed by standards set forth in appropriate chapters of the AEC manual. The radioactivity concentration limits applicable to effluents released from AEC installations are essentially those published in the Federal Register (*1*).

1. Lawrence Radiation Laboratory[1]
January—June 1964

University of California
Berkeley, California

Berkeley Site

The Berkeley site of the Lawrence Radiation Laboratory (LRL) is located to the east of the University of California campus (see figure 1). Technical facilities include a 6.3 Bev proton accelerator (Bevatron), a 700 Mev cyclotron, a linear accelerator of 10 Mev per nucleon, 88-inch cyclotron, and various chemistry and physics laboratories.

The environmental sampling program includes monitoring of the atmosphere, water, and rain or dry deposition. Three types of atmospheric samples are taken: stack samples, local area samples, and perimeter samples. Data for these are shown in table 1.

TABLE 1.—ATMOSPHERIC MONITORING, BERKELEY SITE, JANUARY-JUNE 1964

Sampling locations	Number of samples	Alpha, pc/m³	Beta, pc/m³
Stacks	4,000	0.008	1.37
Local area	248	0	2.00
Perimeter	103	0.001	2.24

Approximately 110 "stacks" with potential for releasing radioactive contaminants are sampled continuously. One-inch diameter filters are used at a flow rate of one liter per minute. The filters are changed weekly and counted for beta activity by an end-window Geiger-Mueller tube and for alpha activity by a thin-window proportional counter. Limits of detection for an individual stack sample were 0.10 pc/m³ alpha and 2.3 pc/m³ beta.

Local area and perimeter air samples are taken at locations on the Laboratory site and at the property line, respectively. The samples are taken on 4 x 9-inch HV–70 filter paper at 4 cfm. The filters are changed weekly, counted for alpha activity by a thin-window proportional counter, and for beta activity by a 30 mg/cm²-window Geiger-Mueller tube. A 40-percent loss in the alpha count is assumed for self adsorption. Limits of detection were 0.15 pc/m³ beta and 0.005 pc/m³ alpha.

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[1] Data from "Environmental Sampling," January through June 1964; methodology summarized from earlier Environmental Sampling reports, Health Chemistry, LRL, Berkeley, California.

Rain or deposition samples are collected monthly in 18-inch diameter cylindrical vessels lined with polyethylene bags at local area and perimeter sites. Deposition data are given in table 2. Rain samples are poured out and evaporated in beakers. If the bag is dry, it is rinsed out with dilute nitric acid; this solution is then evaporated. Final evaporation is conducted in 2-inch diameter stainless steel planchets, which are then flamed and coated with a thin film of lacquer. These planchets are counted for alpha activity in an internal flow proportional counter and for beta activity with a thin-window low-background Geiger-Mueller flow counter. No correction is made for self-absorption in the sample. Detection limits vary, depending on the size of the sample and length of time counted.

TABLE 2.—TOTAL DEPOSITION, BERKELEY SITE, JANUARY-JUNE 1964

Location	Number of samples	Alpha, nc/m²	Beta, nc/m²
Local area	52	0.05	36
Perimeter	23	0.05	31

Water samples are taken from laboratory acid waste systems, onsite streams, and offsite streams. The laboratory waste is sampled at three buildings designated by numbers 70, 71, and 74. At building 70 a continuous sample is collected from the acid waste system for weekly analyses. Samples of approximately two liters each are acidified, evaporated, and counted in the same manner as rain samples. Detection limits were ≤10 pc/liter alpha and beta.

Waste from laboratory areas in building 71 is retained in 350-gallon holding tanks until analyzed. A one-quart sample is taken from each tank and is handled and counted in the same manner as samples taken at building 70.

Surface water is sampled weekly from Strawberry and Blackberry Creeks, which comprise the Laboratory's storm drainage. Two other nearby "offsite" creeks are also sampled weekly. One-quart samples are taken in each case and handled in the same way as rain samples. The sampling stations are shown in figure 1. Results for water samples are shown in table 3.

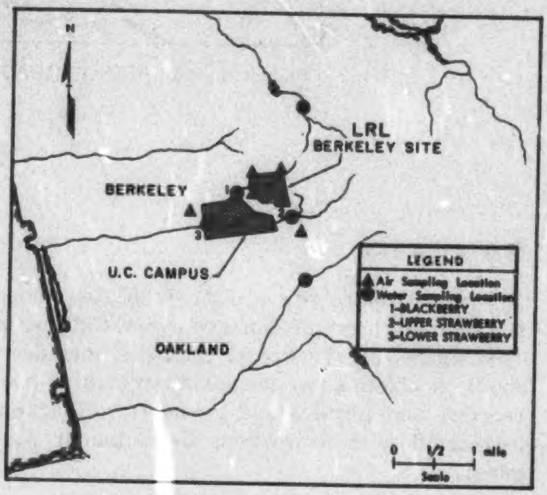

FIGURE 1.—ENVIRONMENTAL SAMPLING LOCATIONS AT THE BERKELEY SITE

TABLE 3.—WATER MONITORING, BERKELY SITE, JANUARY-JUNE 1964

Type of sample	Number of samples	Average concentrations	
		Alpha, pc/liter	Beta, pc/liter
Hearst sewer	59	3.4	45
Sewer, bldg 74	86	<0.43	33
Tap water	25	0.07	8.4
Onsite streams	77	0.49	2.7
Offsite streams	52	0.52	4.1

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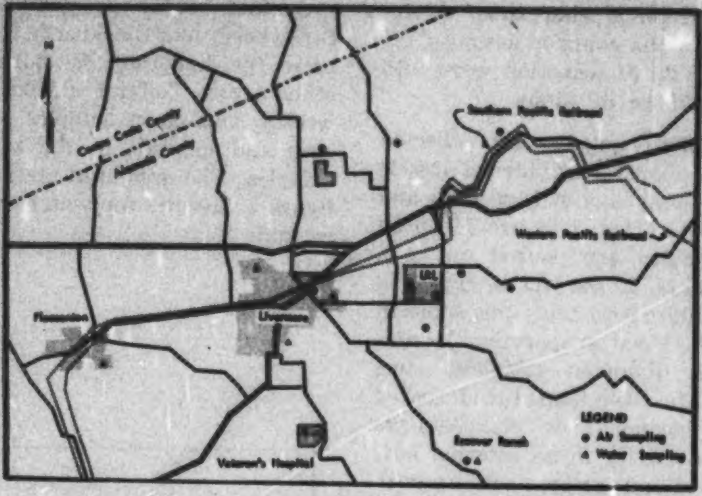

Figure 2.—SAMPLING LOCATIONS AT THE LIVERMORE SITE

Livermore Site

The Livermore site of LRL is located about 50 miles southeast of San Francisco, California (see figure 2). Technical facilities include a small cyclotron, a two-megawatt swimming pool reactor, and physics and chemistry programs associated with a weapons development program.

An environmental sampling program is maintained to provide information regarding the effectiveness of control measures and to determine whether any radiological changes in the environment are the result of laboratory operations. The sampling program includes air particulates, soil, domestic water, sewer effluent, and sewage plant products. Air samples are collected to ascertain that control efforts are restricting the release of radioactivity from the Laboratory to levels which do not exceed the permissible levels for the neighborhood around an atomic energy facility. The water samples are collected to monitor radioactivity in an underground water supply which provides most of the domestic water for the cities of Livermore and Pleasanton, and the sole supply for ranches in the Livermore and Amador Valleys.

Air samples are collected continuously at 11 sites within 5 miles of the Laboratory. Samples are collected at a rate of 4 cfm on 4 x 9-inch HV70 filter papers which are changed every 7 days of operation. A minimum decay period of 96 hours is observed before the papers are counted to eliminate the effect of natural radon and thoron daughters. The alpha activity remaining is measured with a counter equipped with a zinc sulfide scintillation detector with a counting efficiency of about 27 percent for 5.1 Mev. The beta activity is measured with a Geiger-Mueller tube with a counting efficiency of about 12 percent for the 0.54 Mev and 2.27 Mev betas of strontium–90 in equilibrium with yttrium–90. The standards of comparison used are 0.04 pc/m^3 for alpha and 1.0 pc/m^3 for beta, as recommended in NBS Handbook No. 69. The limit of sensitivity is 0.00073 pc/m^3 for alpha and 0.0059 pc/m^3 for beta. Average activity for the eleven air sampling stations which collected 289 samples was 0.0037± 0.0022 pc/m^3 alpha and 0.95±0.05 pc/m^3 beta.

Domestic water samples are collected monthly from two onsite wells and six nearby areas. The average radionuclide concentration in all of the domestic water samples was below the limit of sensitivity for alpha (8.9 pc/liter)

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and for beta (41 pc/liter). The standards of comparison used are 10 pc/liter for alpha and 100 pc/liter for beta, as recommended in the NBS Handbook 69. The gas proportional counter used in these measurements has a counting efficiency of 34 percent for alpha and 40 percent for beta emitters.

Samples of top layer soil are collected quarterly at the 19 sampling stations surrounding the Livermore Site. The alpha activity was below the limit of sensitivity (5.0 pc/g) for all but one sample, which exhibited 5.8 pc/g. The beta activity fluctuated from the limit of sensitivity (23.0 pc/g) to 51.0 pc/g. Sewage samples are collected every Monday, Wednesday, and Friday at the sewer line leaving the southwest project boundary where it connects with the Livermore domestic sewer line. Grab samples are collected monthly at the Livermore Sewage Disposal Plant to assure that liquid effluent from the laboratory is not creating abnormal radioactivity concentrations in the oxidation ponds and dried sludge. The sludge is used as an agricultural soil conditioner. The oxidation ponds overflow into a natural waterway.

Site 300

Site 300 is located in a very sparsely populated ranching area about 17 miles southeast of the Lawrence Radiation Laboratory at Livermore. Air and water samples are taken to determine whether operations at Site 300 are changing the normal concentrations in the vicinity. Lack of power facilities necessitated installation of most of the air samplers within the boundaries of the site. Water samples were taken from onsite wells because they are the only readily accessible source of underground water. During winter, samples are collected from streams only when there is a water flow. All air and water samples are processed at the Laboratory in Livermore.

Air sampling is conducted on a continuous basis at seven stations, but filter papers are changed on an irregular schedule. The standards of comparison for alpha are 1 pc/m³ for the onsite stations and 0.1 pc/m³ for offsite stations located at Tracy, eight miles northeast of Site 300. The standards for beta are 100 pc/m³ onsite and 10 pc/m³ offsite. Average results for all air station samples combined are shown in table 4.

Soil samples are collected monthly at 7 offsite locations. Only top layer soil is collected to determine fallout concentrations. The average soil and water concentrations for the past year are summarized in table 4.

TABLE 4.—ENVIRONMENTAL SAMPLING, SITE 300, JANUARY–JUNE 1964

Type of sample	Number of stations	Number of samples	Average concentrations	
			Alpha	Beta
Air (pc/m³)	7	356	0.0027 ± 0.0013	7.7 ± 0.6
Soil (pc/g)	7	[a] —	5	24
Onsite wells (pc/liter)	6	—	[b] ND	ND
Offsite streams (pc/liter)	3	—	ND	ND

[a] Dash indicates data not available.
[b] ND indicates activity not detectable.

Recent coverage in *Radiological Health Data:*

Period	Issue
Second half 1961	*October 1962*
Calendar Year 1962	*October 1963*
Calendar Year 1963	*October 1964*

2. Mound Laboratory,[2]
January—June 1964

Monsanto Research Corporation

Of the radionuclides in use at Mound Laboratory at Miamisburg, Ohio, only polonium–210, plutonium–239, and hydrogen–3 (tritium) are potential environmental contaminants. No measurable amounts of penetrating radiation such as gamma or hard beta have been contributed to the environment by the Laboratory during the period covered by this report.

The environmental monitoring program, conducted by the Monsanto Research Corporation, is planned and coordinated with regard to all of the various projects performed in the Laboratory. Water and air monitoring methods and results are discussed below.

Air monitoring

A continuous air monitor for measurement of tritium and particulate air sampling equipment for measurement of alpha activity are mounted on a one-ton panel truck for use in the routine monitoring of the environmental air at 104 locations selected within a radius of 20 miles. The choice of sites on a given day depends on the wind direction at the time of collection.

During the six-month period ending June 1964, 246 samples were taken for determination of tritium in air. In all cases tritium was nondetectable.

Monitoring for possible polonium–210 and plutonium–239 released to the environment is accomplished by determination of long-lived gross alpha activity on filter paper samples. Counting is done in a low-background proportional counter. Sufficient delay time is allowed after collection to minimize interference from the daughter products of radon and thoron. The measured concentrations of alpha activity in air are summarized in table 5.

TABLE 5.—LONG-LIVED ALPHA CONCENTRATIONS IN AIR IN THE MOUND LABORATORY ENVIRONMENT

Direction from laboratory relative to wind	First half 1964	
	Number of samples	Alpha, pc/m^3
Upwind	243	0.0024
Downwind	40	0.0025

No specific determinations of polonium–210 or plutonium–239 were made, since the alpha activity remained substantially below the environmental MPC's for these nuclides.

It may be observed that there is no significant difference between upwind and downwind average alpha activity for the first half 1964. The gross alpha air concentration averaged over the 6-month period was 3.8 percent of the environmental MPC for plutonium.

Water monitoring

Liquid radioactive waste materials from polonium operations at the Laboratory are processed in a special waste disposal plant designed to reduce radioactivity to a concentration level at which it may be discharged to the Great Miami River (station 2, figure 3). Liquid waste from plutonium work is small in volume, is handled separately as a packaged waste, and is not discharged to the river. Helium–3, which is purified at the Mound Laboratory, contains small quantities of tritium. Liquid wastes from this work, also small in volume, are treated separately (diluted with water when necessary) to assure that the radioactivity content is below the maximum permissible concentration before discharge to the Great Miami River.

Weekly water samples are collected from a drainage ditch and five locations along the Great Miami River as shown in figure 3. The drainage ditch carries away all storm sewer water and liquid tritium wastes from the plant site. Sampling location number 2 is located at the point of discharge of the laboratory effluent to the Great Miami River, and number 6 is five miles downstream from the effluent outlet.

All of the river samples are analyzed for polonium–210. The drainage ditch samples and some of the river samples are analyzed for tritium. Average concentrations of tritium and polonium–210 are given in table 6. The highest polonium–210 concentration during the 6-month period was 19 pc/liter in a sample taken from station 4 collected during the first half of 1964; the average was 0.24 percent of the MPC for polonium–210. The highest tritium value found in a sample was 2 million pc/liter; the average was 2.6 percent of the MPC for the general population.

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[2] Summarized from Environmental Monitoring Semi-Annual Report, January–June 1964 (MLM–1210) July 24, 1964.

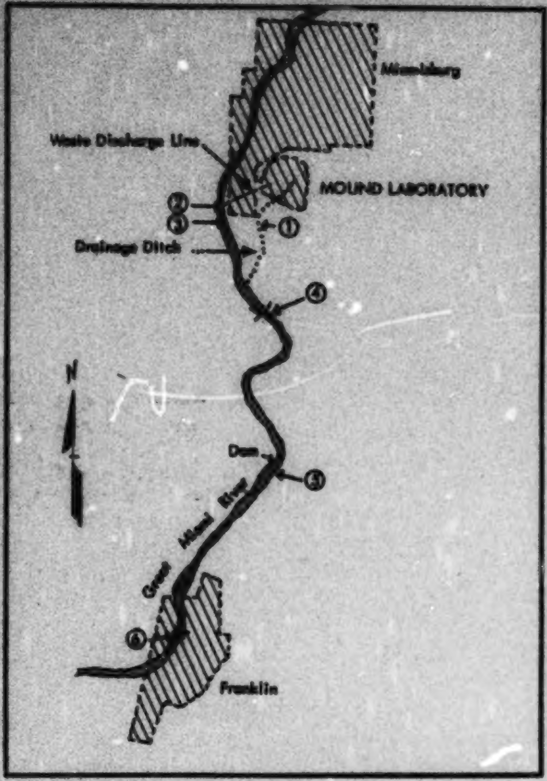

FIGURE 3.—WATER SAMPLING LOCATIONS IN GREAT MIAMI RIVER, MOUND LABORATORY

TABLE 6.—OFFSITE WATER MONITORING FOR POLONIUM-210 AND TRITIUM FROM MOUND LABORATORY

Nuclide and station number (see figure 3)	First half 1964	
	Number of samples	Average concentration, pc/liter
Polonium-210		
2 (effluent)	16	2.7
3	15	0.9
4	16	2.3
5	16	0.9
6	15	1.8
Hydrogen-3 (tritium)		
1 (drainage ditch)	17	300,000
2 (effluent)	15	0.0
4	15	70,000

REFERENCE

(*1*) U.S. ATOMIC ENERGY COMMISSION. Rules and regulations, standards for protection against radiation, Title 10, Part 20, Appendix B, Table 2. U.S. Government Printing Office, Washington, D.C. 20402.

Recent coverage in *RHD:*

Period	Issue
January–June 1962	*March 1963*
July 1962–June 1963	*April 1964*
July–December 1963	*November 1964*

REPORTED NUCLEAR DETONATIONS, APRIL 1965

During April 1965 three underground nuclear tests at the Nevada Test Site were announced by the Atomic Energy Commission. The first test, conducted on April 5, was of low-intermediate yield (20-200 kilotons); tests conducted on the fourteenth and twenty-first were of low yield (less than 20 kilotons).

The test of April 14 was a nuclear excavation experiment of the Commission's "Plowshare Program" for developing peaceful uses for nuclear explosives. The yield of the nuclear explosive was about 4 kilotons. As announced by the Commission, "Most of the radioactivity from the experiment remained underground. Some radioactivity was released. This was only a small fraction of the radioactivity which was produced, and most of it was deposited in the vicinity of the experiment. The very small amount of radioactivity released off-site does not constitute a health hazard."

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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service • Division of Radiological Health

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Section I—Air and Fallout

GROSS BETA ACTIVITY IN AIRBORNE PARTICULATES AND PRECIPITATION

Continuous surveillance of gross beta activity in air and precipitation provides one of the earliest and most sensitive indications of changes in environmental fission product activity. Although this surveillance does not provide enough information to assess human radiation exposure from fallout, it is used as an alerting system for determining when to intensify monitoring in other phases of the environment.

Surveillance data from a number of national programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. Data provided by programs of the Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization are presented individually in tabular form.

1. Radiation Surveillance Network
February 1965

Division of Radiological Health,
Public Health Service

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Surveillance Network (RSN) of the PHS Division of Radiological Health, which regularly gathers samples from 75 stations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

Alerting function

The alerting function of the network is provided by field estimates of the gross beta activity of airborne particulates on the filters. These determinations are performed about 5 hours after the end of the sampling period to allow for decay of naturally occurring radon daughters. The network station operators regularly submit their field estimates to the Radiation Surveillance Center, Division of Radiological Health, Washington, D. C. These field estimates are reported elsewhere on a monthly basis (*1*). When unusually high air levels are reported, appropriate Federal and State officials are promptly notified.

Air sampling procedure and results

Airborne particulates are collected continuously on carbon-loaded cellulose dust filters 4 inches in diameter. About 1800 cubic meters of air is drawn through each filter during the 24-hour sampling period by a high volume centrifugal blower.

The filters are forwarded to the Radiation Surveillance Network laboratory in Rockville, Maryland, where the gross beta activity is measured using a thin-window, gas-flow proportional counter, calibrated with a ^{90}Sr–^{90}Y standard. Each filter is counted 4 days after the end of the sampling period and again 7 days later if the net count rate is 2,000 cpm or higher. The initial 4-day aging of the sample eliminates intereference from naturally occurring radon and thoron daughters. By using the two counts and the Way-Wigner formula (*2*),

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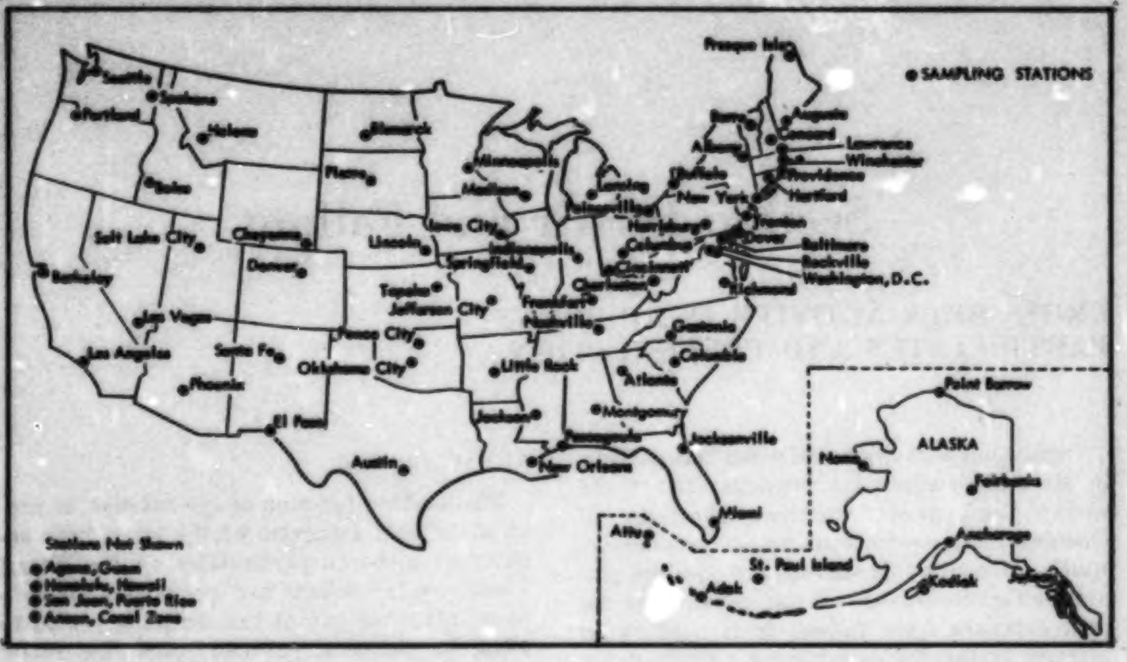
Presque Isle
SAMPLING STATIONS
Seattle
Spokane
Portland
Helena
Bismarck
Augusta
Barre
Concord
Lawrence
Winchester
Albany
Providence
Minneapolis
Pierre
Madison
Buffalo
Lansing
Hartford
New York
Boise
Painesville
Trenton
Harrisburg
Iowa City
Dover
Columbus
Baltimore
Salt Lake City
Cheyenne
Lincoln
Indianapolis
Rockville
Springfield
Cincinnati
Washington, D.C.
Denver
Charleston
Berkeley
Topeka
Richmond
Frankfort
Jefferson City
Nashville
Las Vegas
Gastonia
Kansas City
Santa Fe
Columbia
Los Angeles
Oklahoma City
Little Rock
Atlanta
Point Barrow
Phoenix
El Paso
Jackson
Montgomery
ALASKA
Jacksonville
Nome
Pensacola
Austin
New Orleans
Fairbanks
Miami
Attu
Anchorage
St. Paul Island
Stations Not Shown
Agana, Guam
Honolulu, Hawaii
San Juan, Puerto Rico
Ancon, Canal Zone
Adak
Kodiak
Juneau

FIGURE 1.—RADIATION SURVEILLANCE NETWORK SAMPLING LOCATIONS

the age of fission products is estimated, and the activity extrapolated to the time of collection.[1] The daily concentrations and estimated ages of selected samples are reported by the PHS in a monthly RSN report (*1*). Table 1 presents average gross beta concentrations in air determined from February 1965 RSN air filters.

Time profiles of gross beta activity in air dating back to 1958 for eight RSN stations are shown in figure 2.

During February 1965, two air samples were analyzed by gamma spectroscopy. The method discussed by Burrus (*3*) and Covell (*4*) was adapted for resolving the complex gamma scan data. No air or precipitation samples were found to contain short-lived radionuclides.

Precipitation measurements

Continuous sampling for radioactivity in total precipitation is conducted at most stations on a daily basis, using funnels with collection areas of 0.4 square meter. A 500-ml portion of the collected precipitation is evaporated to dryness, and the residue is forwarded to the laboratory for analysis. If the collected sample is between 200 and 500 ml, the entire sample is evaporated. When a sample is smaller than 200 ml (equivalent to 0.5 mm or 0.02 inches of rainfall), the volume of precipitation is reported, but no analysis is made.

In the laboratory the gross beta activity in precipitation is determined by counting the evaporated sample by the same method used for analyzing the air filters, including the extrapolation to time of collection. Deposition for the sample is determined by:

$$D = \frac{CP}{1000}$$

where D is the deposition in nCi/m², C is the concentration in pCi/liter, and P is the depth of precipitation in mm. The individual values of deposition and depth of precipitation are totaled for the month. The February 1965 depths and total depositions are given in table 1.

---

[1] If a sample contains a mixture of fresh and old fission products, the age estimated by the Way-Wigner formula is some intermediate value; consequently the calculated age of the fresh component will be overestimated.

TABLE 1.—GROSS BETA ACTIVITY IN SURFACE AIR AND PRECIPITATION, FEBRUARY 1965

Station location		Air surveillance					Precipitation measurements	
		Number of samples	Gross beta activity, pCi/m³			Last profile in *RHD*	Total depth (mm)	Total deposition nCi/m²
			Maximum	Minimum	Average [a]			
Ala:	Montgomery	27	0.50	<0.10	0.28	May 65	177.7	48.3
Alaska:	Adak	17	0.53	<0.10	<0.16	Nov 64	[b]	[b]
	Anchorage	27	0.31	<0.10	0.19	May 65	6.2	1.3
	Attu Island	3	0.28	<0.10	<0.15	Dec 64		
	Fairbanks	15	0.34	<0.10	0.15	Jun 65	9.0	1.8
	Juneau	3	0.10	<0.10	<0.10	Sep 64		
	Kodiak	17	0.48	<0.10	<0.19	Oct 64		
	Nome	22	0.22	<0.10	0.18	Feb 65		
	Point Barrow	27	0.38	<0.10	<0.13	Jan 65		
	St. Paul Island	27	0.26	<0.10	<0.15	Mar 65		
Ariz:	Phoenix	25	0.52	<0.10	0.32	Sep 64		
Ark:	Little Rock	24	0.33	<0.10	0.20	Jun 65	115.6	22.2
Calif:	Berkeley	26	0.43	<0.10	0.20	Oct 65	24.0	4.8
	Los Angeles	28	0.73	<0.10	0.35	Feb 65	8.4	1.7
C. Z:	Ancon	14	0.15	<0.10	<0.11	Nov 64		
Colo:	Denver	25	0.52	<0.10	0.26	Oct 64	6.5	1.4
Conn:	Hartford	26	0.55	<0.10	0.26	Oct 64	77.0	16.6
Del:	Dover	19	0.50	<0.10	0.24	May 65		
D. C:	Washington	25	0.62	<0.10	0.31	Feb 65	46.3	9.3
Fla:	Jacksonville	25	0.70	<0.10	0.29	Jun 65	175.2	37.0
	Miami	27	0.67	<0.10	0.31	Oct 64	98.8	21.6
Ga:	Atlanta	23	0.48	<0.10	<0.18	Apr 65	49.5	10.0
Guam:	Agana	27	0.41	<0.10	0.21	Apr 65		
Hawaii:	Honolulu	28	0.51	<0.10	0.30	Dec 64	34.2	6.9
Idaho:	Boise	27	0.28	<0.10	0.20	Dec 64	9.9	2.7
Ill:	Springfield	27	0.65	<0.10	0.27	Feb 65		
Ind:	Indianapolis	25	0.40	<0.10	0.25	Apr 65	96.0	19.1
Iowa:	Iowa City	27	0.51	<0.10	0.28	Nov 64	23.8	5.0
Kans:	Topeka	26	0.36	<0.10	0.18	May 65	21.0	4.3
Ky:	Frankfort	24	0.52	<0.10	0.34	Feb 65	38.2	8.6
La:	New Orleans	27	0.28	<0.10	0.16	Feb 65	118.7	27.7
Maine:	Augusta	27	0.81	0.21	0.32	Mar 65	132.1	27.8
	Presque Isle	4	0.41	<0.10	0.26	Nov 64		
Md:	Baltimore	15	0.46	<0.10	0.26	Oct 64	27.5	5.5
	Rockville	5	0.39	0.13	0.22	Jan 65		
Mass:	Lawrence	25	0.80	<0.10	0.30	May 65	52.6	11.9
	Winchester	24	0.66	0.13	0.38	Dec 64	58.3	15.3
Mich:	Lansing	23	0.70	0.17	0.35	Jan 65		
Minn:	Minneapolis	21	0.30	<0.10	0.17	Apr 65	28.1	7.6
Miss:	Jackson	27	0.45	<0.10	0.22	Mar 65	108.4	24.9
	Pascagoula	17	0.48	<0.10	0.25	Dec 64		
Mo:	Jefferson City	27	0.35	<0.10	0.17	Apr 65	25.9	5.3
Mont:	Helena	23	0.58	<0.10	0.25	Nov 64	12.3	2.5
Nebr:	Lincoln	19	2.58	<0.10	0.34	Mar 65		
Nev:	Las Vegas	19	0.74	0.13	0.34	Jun 65		
N. H:	Concord	18	0.60	<0.10	0.22	Feb 65		
N. J:	Trenton	26	0.53	<0.10	0.29	Mar 65	13.3	2.9
N. Mex:	Santa Fe	24	0.50	<0.10	0.24	Nov 64	24.3	4.7
N. Y:	Albany	19	0.40	<0.10	0.25	Apr 65	28.6	5.9
	Buffalo	19	0.66	0.15	0.35	Nov 64		
	New York	22	0.96	<0.10	0.29	Dec 64		
N. C:	Gastonia	26	0.78	<0.10	0.35	Nov 64	87.2	18.3
N. Dak:	Bismarck	27	0.30	<0.10	0.17	Jan 65	2.5	0.5
Ohio:	Cincinnati	17	0.71	<0.10	0.26	May 65		
	Columbus	24	0.84	<0.10	0.42	Mar 65	66.6	13.4
	Painesville	27	0.77	0.14	0.37	Oct 64	56.5	17.0
Okla:	Oklahoma City	23	0.37	<0.10	0.16	Jan 65	8.3	4.1
	Ponca City	25	0.28	<0.10	<0.13	Oct 64	15.4	3.6
Oreg:	Portland	27	1.13	<0.10	0.30	Mar 65	46.7	10.1
Pa:	Harrisburg	27	0.52	<0.10	0.24	Apr 65	17.8	7.0
P. R:	San Juan	23	0.36	<0.10	0.17	Mar 65	34.4	9.6
R. I:	Providence	26	0.80	<0.10	0.30	Jan 65	96.1	19.3
S. C:	Columbia	25	0.54	<0.10	0.38	Dec 64	157.0	38.9
S. Dak:	Pierre	27	0.36	<0.10	0.17	Sep 64		
Tenn:	Nashville	26	0.55	<0.10	0.30	Jan 65	117.2	24.4
Tex:	Austin	27	0.49	<0.10	0.21	May 65	146.8	33.0
	El Paso	27	0.73	0.18	0.40	Jan 65	10.5	2.2
Utah:	Salt Lake City	27	1.08	<0.10	0.30	Feb 65	28.9	5.3
Vt:	Barre	26	0.62	0.13	0.39	Jun 65	41.8	9.2
Va:	Richmond	28	0.35	<0.10	0.21	Jun 65	83.8	16.9
Wash:	Seattle	25	0.40	<0.10	<0.16	May 65	90.3	14.3
	Spokane	28	0.48	<0.10	0.18	Apr 65		
W. Va:	Charleston	27	0.62	<0.10	0.34	Dec 64	45.2	9.8
Wis:	Madison	27	0.56	<0.10	0.29	Jun 65	24.0	7.9
Wyo:	Cheyenne	25	0.53	<0.10	0.23	Jun 65	3.5	0.7
Network summary [c]		1,736	2.58	<0.10	<0.25		55.3	12.3

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[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If the <0.10 values represent more than 10 percent of the values used in the average, a less-than sign is placed before the average.

[b] Blank indicates no report received.

[c] For the network summary, all averages are arithmetic means of station averages.

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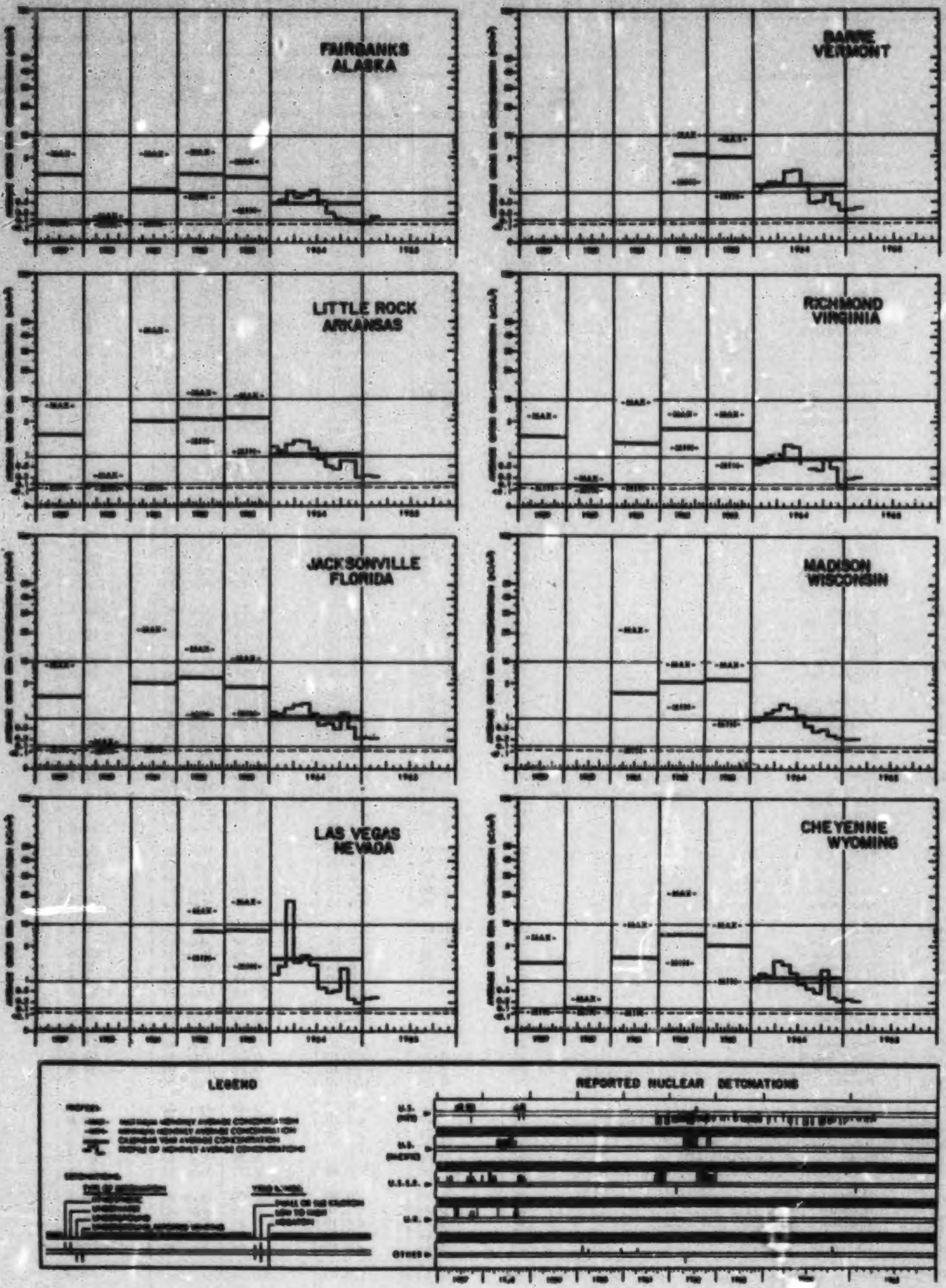

FIGURE 2.—MONTHLY AND YEARLY PROFILES OF BETA ACTIVITY IN AIR—RADIATION SURVEILLANCE NETWORK, 1959–FEBRUARY 1965

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2. Canadian Air Monitoring Program[2] February 1965

Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (see figure 3), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*5-9*).

Air

Each air sample involves the collection of particulates from about 650 cubic meters of air drawn through a high-efficiency 4-inch diameter glass-fiber filter during a 24-hour period. These filters are sent daily to the Radiation Protection Division Laboratory in Ottawa. At the laboratory, a 2-inch-diameter disk is cut from each filter and counted with a thin-end-window, gas-flow, Geiger-Mueller counter system calibrated with a ^{90}Sr–^{90}Y standard. Four successive measurements are made on each filter to permit correction for natural activities and for the decay of short-lived fission products. The results are extrapolated to the end of the sampling period. Canadian air data for February 1965 are given in table 2.

Precipitation

The amount of radioactive fallout deposited on the ground is determined from measurements on material collected in special polyethylene-lined rainfall pots. The collection period for each sample is one month. After transfer of the water to the sample container, the polyethylene liner is removed, packed with the sample, and sent to the laboratory.

Strontium and cesium carriers are added to all samples on arrival at the laboratory. Other carriers are also added to selected samples according to the specific radionuclides to be determined. The samples are then filtered and the filtrate evaporated to near dryness. The filter paper containing insoluble matter is ignited together with the polyethylene liner at 450 degrees C. The ash is combined with the soluble fraction, transferred to a glass planchet, evaporated under an infra-red lamp, and then counted with a thin-end-window Geiger-Mueller counter calibrated with a ^{90}Sr–^{90}Y source. Gross beta activities for February 1965 samples are given in table 2. Radionuclide analyses are reported quarterly in *RHD*.

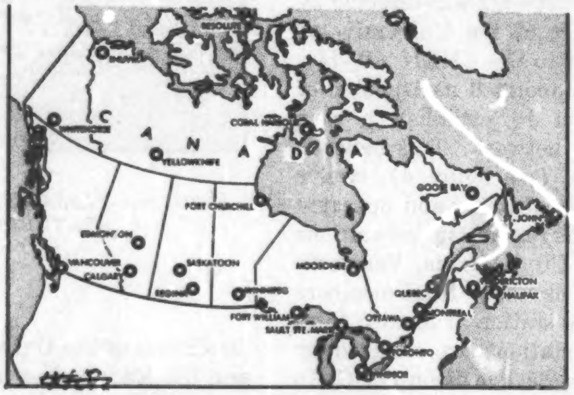

FIGURE 3.—CANADIAN AIR AND PRECIPITATION SAMPLING STATIONS

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[2] Data from RADIATION PROTECTION DIVISION. *Radiation Protection Programs*, Vol. 3, No. 3: 16–24 (March 1965), Canadian Department of National Health and Welfare, Ottawa, Canada.

TABLE 2.—GROSS BETA ACTIVITY IN SURFACE AIR AND PRECIPITATION, CANADA, FEBRUARY 1965

Station location	Air surveillance				Precipitation measurements	
	Number of samples	Gross beta activity, pCi/m³			Average concentration, pCi/liter	Total deposition nCi/m²
		Maximum	Minimum	Average		
Calgary	28	0.5	0.0	0.2	221	3.6
Coral Harbour	28	0.3	0.0	0.2	373	1.7
Edmonton	28	0.3	0.1	0.2	149	3.9
Ft. Churchill	17	0.4	0.1	0.3	151	1.3
Ft. William	28	0.5	0.2	0.3	118	5.8
Fredericton	26	0.3	0.1	0.3	40	3.4
Goose Bay	28	0.4	0.1	0.2	47	2.3
Halifax	28	0.3	0.1	0.2	46	5.2
Inuvik	28	0.4	0.1	0.3	190	1.4
Montreal	28	0.4	0.2	0.3	81	6.0
Moosonee	28	0.4	0.1	0.3	43	1.5
Ottawa	27	0.4	0.1	0.3	66	5.7
Quebec	28	0.4	0.1	0.3	100	14.4
Regina	28	0.4	0.1	0.2	81	2.7
Resolute	26	0.3	0.0	0.2	43	3.0
St. John's, Nfld	28	0.4	0.0	0.2	66	5.4
Saskatoon	14	0.2	0.1	0.1	88	1.4
Sault Ste. Marie	26	0.6	0.0	0.3	77	6.3
Toronto	28	0.5	0.1	0.3	81	6.3
Vancouver	28	0.4	0.0	0.1	110	19.7
Whitehorse	28	0.4	0.1	0.2	45	0.9
Windsor	27	0.5	0.1	0.3	46	4.2
Winnipeg	27	0.4	0.2	0.2	209	2.9
Yellowknife	28	0.4	0.1	0.2	117	0.8
Network summary	640	0.4	0.0	0.2	112	4.6

3. Mexican Air Monitoring Program February 1965

National Commission of Nuclear Energy

The Radiation Surveillance Network of Mexico was established by the Comisión Nacional de Energía Nuclear (CNEN), Mexico City. From 1952 to 1961 the network was directed by the Institute of Physics of the University of Mexico, under contract to the CNEN (*10-14*).

In 1961 the CNEN appointed its Division of Radiological Protection to establish a new Radiation Surveillance network. This network consists of 17 stations (see figure 4), twelve of which are located at airports and operated by airline personnel. The remaining five stations are located at Mexico City, Mérida, Veracruz, San Luis Potosí, and Ensenada. Staff members of the DRP operate the station at Mexico City, while the other four stations are manned by members of the Centro de Previsión del Golfo de México, the Chemistry Department of the University of Mérida, the Institute de Zonas Desérticas of the University of San Luis Potosí, and the Escuela Superior de Ciencias Marinas of the University of Baja California, respectively.

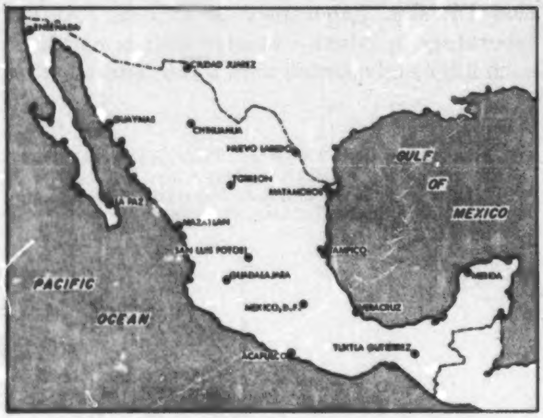

FIGURE 4.—FALLOUT NETWORK SAMPLING STATIONS IN MEXICO

Sampling

The sampling procedure involves drawing air for 24-hours a day, 3 or 4 days a week at the rate of approximately 1,200 cubic meters per day, through a high-efficiency, 6 x 8-inch glass fiber filter, using high volume samplers. After each 24-hour sampling period, the filter is removed and forwarded via airmail to the "Laboratorio de Estudios sobre Contaminación Radiactiva", CNEN, in Mexico City for assay of gross beta activity. A minimum of 3 or 4 days after collection is allowed for decay of radon and thoron daughter natural radioactivity. Data are not extrapolated to time of collection.

Results

The maximum, minimum, and average fission product beta concentrations in surface air during February 1965 are presented in table 3.

TABLE 3.—GROSS BETA ACTIVITY OF AIRBORNE PARTICULATES, MEXICO, FEBRUARY 1965

Station	Number of samples	Gross beta activity, pCi/m³		
		Maximum	Minimum	Average
Acapulco	5	[a]	<0.1	0.1
Ciudad Juárez	7	0.2	0.1	0.1
Chihuahua	9	0.1	<0.1	0.2
Ensenada	3	0.2	0.1	0.1
Guadalajara	2	0.1	<0.1	0.1
Guaymas	0			
La Paz	0			
Matamoros	2	<0.1	<0.1	<0.1
Mazatlán	0			
Mérida	3	0.1	<0.1	0.1
México, D.F.	5	0.1	<0.1	0.1
Nuevo Laredo	4	0.1	<0.1	<0.1
San Luis Potosí	12	0.2	0.1	0.1
Tampico	13	0.9	<0.1	0.2
Torreón	13	0.5	0.1	0.2
Tuxtla Gutiérrez	0			
Veracruz	5	0.3	<0.1	0.1

[a] Blanks indicate stations temporarily shut down.

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4. Pan American Air Sampling Program
February 1965

Pan American Health Organization and Public Health Service

Gross beta activity in air is monitored by five countries in the Americas under the auspices of a collaborative program, developed by the Pan American Health Organization and the Public Health Service (PHS), for assisting countries of the Americas in developing radiological health programs. The sampling equipment and analytical services are provided by the Division of Radiological Health, PHS, and are identical with those employed for the Radiation Surveillance Network.

The five air sampling stations included in the Program are operated by the technical staff of the Ministry of Health in each country. The station in Kingston, Jamaica, is operated by the Public General Hospital; in Caracas, Venezuela, by the Venezuelan Institute for Scientific Investigations; in Lima, Peru, by the Institute of Occupational Health; in Santiago, Chile, by the Occupational Health Service; and in Trinidad, West Indies, by the University of the West Indies.

The February 1965 air monitoring results from the five participating countries are given in table 4.

TABLE 4.—GROSS BETA ACTIVITY IN AIR, PAHO, FEBRUARY 1965

Sampling stations	Number of samples	Gross beta activity, pCi/m³		
		Maximum	Minimum	Average [a]
Kingston, Jamaica	8	0.16	<0.10	0.12
Caracas, Venezuela	20	0.11	<0.10	<0.10
Lima, Peru	8	0.22	<0.10	<0.12
Santiago, Chile	27	0.30	<0.10	<0.14
Trinidad, West Indies	15	0.17	<0.10	<0.11

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If the <0.10 values represent more than 10 percent of the values used in the average, a less-than sign is placed in front of the average.

5. Gross Beta Activity in Air, North America February 1965

From January 1963 through March 1965, monthly average concentrations of airborne gross beta activity in Canada and the United States were presented in combined form as isogram maps of most of North America. The data from the Radiation Surveillance Network and the Canadian Air Network were adjusted to each other by means of an intercalibration factor derived by Lockhart and Patterson (*15*).

With the formation of the Mexican Air monitoring program, new intercalibration ratios were determined, this time including the Canadian Network, Radiation Surveillance Network, Pan American Air Sampling Program, National Air Sampling Network, the HASL 80th Meridian Network, and the Mexican Network (*16*). The new intercalibration factors reflect some changes in standardization in both the RSN and the Canadian Air Network, effective September 1963.

In recent months, airborne gross beta activities have declined to such low levels that isogram comparisons are no longer meaningful. Before comparison with each other, the data must be multiplied by appropriate intercalibration factors. For example, if the Canadian data are considered as unity, the RSN and Pan American data must be multiplied by the intercalibration factor, 1.28, and the Mexican data must be multiplied by 0.81.

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FISSION PRODUCT GAMMA ACTIVITY IN SURFACE AIR— 80th MERIDIAN AND U.S. LOCATIONS, JULY-NOVEMBER 1964[1]

Health and Safety Laboratory
Atomic Energy Commission

Since January 1, 1963, surface air filter samples have been collected for total gamma activity determinations as part of the HASL (Health and Safety Laboratory) 80th Meridian Network program. This network consists of fourteen air sampling stations near the 80th Meridian (West) from Thule, Greenland, to Punta Arenas, Chile (figure 1). An additional station at Mauna Loa, Hawaii, is included for comparison of data with the Chacaltaya, Bolivia station. These stations are both at high elevations and are at approximately equal north and south latitudes, respectively.

In August 1963, six additional air sampling stations were added to the HASL Network in North America (*1*). As with the original 80th Meridian Network sampling stations, both air filter and deposition samples are collected. While surface air data are reported on a monthly basis, the deposition data are reported quarterly.

Sampling and analysis procedures

Air particulates are sampled on 8-inch-diameter polystyrene (Microsorban) filters, drawing air through the filters continuously at the rate of about 1,400 cubic meters per day. Filters are changed on the 1st, 8th, 15th, and 22nd of each month and forwarded to HASL for analysis. A total gamma count over the energy range, 0–3 Mev, is made approximately two weeks after the end of the sampling period, using an 8 x 4-inch sodium iodide (thallium-activated) crystal. The filters are then composited on a monthly basis and analyzed radiochemically, together with monthly ground deposition samples taken at the same site, for detectable fission and neutron activation products.

Results and discussion

The results of total gamma activity determinations in weekly ground level air filter samples taken at 80th Meridian Network stations during July through November 1964 are given in tables 1–5, together with average monthly activity concentrations calculated for each site. The average monthly activities are also plotted in figures 2–4 as activity-latitude profiles.

There was a marked decrease in gamma activity in July 1964 at most stations. Surface air activities in the Northern Hemisphere ranged from 0.03 to 1.02 $\gamma/\text{min}/\text{m}^3$ (photons per minute per cubic meter) and averaged 0.43 $\gamma/\text{min}/\text{m}^3$. In the Southern Hemisphere, the range was from 0.01 to 0.09 $\gamma/\text{min}/\text{m}^3$. In comparison with previous data, the July 1964 averages represent a 42 percent decrease in the

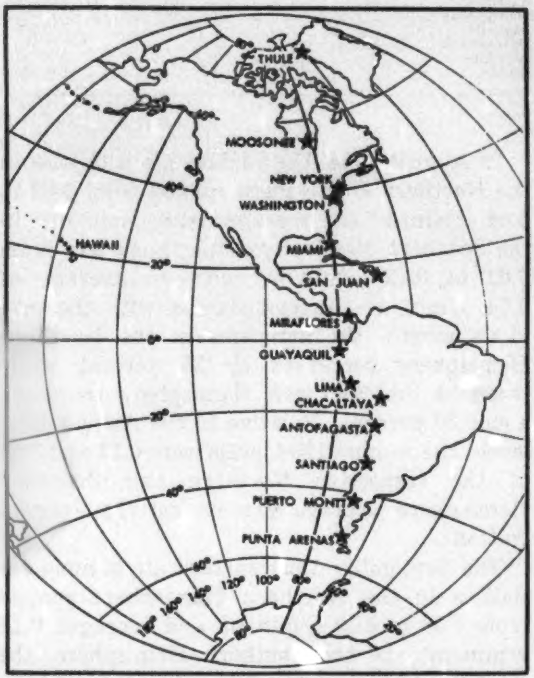

FIGURE 1.—80TH MERIDIAN NETWORK SAMPLING STATIONS

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[1] This report was developed from information and data in the November 1964 through March 1965 monthly reports entitled "80th Meridian Network, Results of Air Sampling Measurements." These reports are furnished by the Health and Safety Laboratory, AEC, New York, N. Y. 10014

Northern Hemisphere and less than a 3 percent decrease in the Southern Hemisphere with respect to the previous month. The July 1964 gamma activity concentrations expressed in terms of the respective July 1963 average levels were 0.12 of those observed in the Northern Hemisphere and 0.38 of those observed in the Southern Hemisphere.

TABLE 1.—GAMMA ACTIVITY IN SURFACE AIR, JULY 1964

[Gamma activity, photons/min/m³]

Sampling site	Date filter changed				
	8	15	22	31	Average
Thule	0.0946	0.103	0.184	0.0993	0.115
Moosonee	0.956	0.684	0.536	0.531	0.675
New York	0.936	0.488	0.617	0.332	0.606
Washington	0.480	0.502	1.02	0.274	0.543
Miami	0.385	0.460	0.333	0.276	0.345
Mauna Loa	0.386	0.372	0.311	0.283	0.332
San Juan	0.417	0.359	0.441	0.400	0.404
Miraflores	0.0460	0.0530	0.115	0.0274	0.0571
Guayaquil	0.0255	0.0228	0.0250	0.0344	0.0278
Lima	0.0229	0.0558	0.0602	0.0525	0.0473
Chacaltaya	0.0911	0.0609	0.0229	0.0570	0.0566
Antofagasta	0.0500	0.0650	0.0674	0.0867	0.0713
Santiago	0.0333	0.0302	0.0191	0.0133	0.0238
Puerto Montt	0.0306	0.0166	0.0103	0.0175	0.0187
Punta Arenas	0.0293	0.0163	0.0164	0.0114	0.0177
Additional U.S. Sites:					
Westwood					0.474
Chattanooga					0.505
Appleton					0.568
Midwest City					0.645
Palo Alto					0.437
Seattle					0.266

In August 1964, the surface air activities in the Northern Hemisphere ranged from 0.02 to 0.48 γ/min/m³ and averaged 0.28 γ/min/m³. In the Southern Hemisphere, the range was from 0.01 to 0.12 γ/min/m³ with an average of 0.04 γ/min/m³. In comparison with the previous month, the activities in the Northern Hemisphere decreased by 35 percent while those in the Southern Hemisphere increased about 20 percent. Relative to the August 1963 levels, the August 1964 levels were 0.11 and 0.45 of the respective Northern and Southern Hemisphere average gamma activity concentrations.

The September 1964 surface air gamma activities in the Northern Hemisphere ranged from 0.03 to 0.62 γ/min/m³ and averaged 0.18 γ/min/m³. In the Southern Hemisphere, the range was from 0.01 to 0.09 γ/min/m³, with an average of 0.064 γ/min/m³. In comparison with the previous month, the average surface air activities in the Northern Hemisphere decreased by 36 percent while in the Southern Hemisphere an increase of about 39 percent was noted. Relative to the September 1963 levels, the September 1964 levels were 0.16 and 0.71 of the respective Northern and Southern Hemisphere average gamma activity concentrations.

TABLE 2.—GAMMA ACTIVITY IN SURFACE AIR, AUGUST 1964

[Gamma activity, photons/min/m³]

Sampling site	Date filter changed				
	8	15	22	31	Average
Thule	0.542	0.498	0.569	0.302	0.467
Moosonee	0.294	0.301	0.113	0.285	0.253
New York	0.501	0.420	0.371	0.375	0.442
Washington	0.524	0.332	0.407	0.303	0.383
Miami	0.347	0.110	0.208	0.0967	0.198
Mauna Loa	0.212	0.129	0.180	0.113	0.155
San Juan	0.571	0.142	no sample	0.111	0.257
Miraflores	0.0313	0.0567	0.0699	0.0396	0.0479
Guayaquil	0.0218	0.0144	0.0338	0.0351	0.0271
Lima	0.0426	0.0834	0.0455	0.0782	0.0473
Chacaltaya	0.0760	0.0740	0.0541	0.0536	0.0630
Antofagasta	0.0107	0.0914	0.0811	0.0895	0.0919
Santiago	0.0865	0.0408	0.0357	0.0582	0.0543
Puerto Montt	0.0133	0.0104	0.0319	0.0204	0.0192
Punta Arenas	0.0168	0.0115	0.0171	0.0238	0.0179
Additional U.S. Sites:					
Westwood	0.623	0.526	0.440	0.302	0.452
Chattanooga	0.412	0.333	0.342	0.311	0.348
Appleton	0.387	0.323	0.339	0.274	0.325
Midwest City	0.284	0.411	0.315	0.276	0.317
Palo Alto	0.174	0.198	0.223	0.206	0.203
Seattle	0.167	0.105	0.157	0.214	0.161

TABLE 3.—GAMMA ACTIVITY IN SURFACE AIR, SEPTEMBER 1964

[Gamma activity, photons/min/m³]

Sampling site	Date filter changed				
	8	15	22	30	Average
Thule	0.233	0.259	0.405	0.337	0.309
Moosonee	0.265	0.141	0.196	0.0932	0.169
New York	0.364	0.336	0.330	0.173	0.281
Washington	0.427	0.295	0.310	0.164	0.290
Miami	0.178	0.138	0.135	0.0850	0.131
Mauna Loa	0.0811	0.197	0.145	0.0734	0.125
San Juan	0.170	0.108	0.0640	0.107	0.112
Miraflores	0.0257	0.0345	0.0248	0.0147	0.0243
Guayaquil	0.0256	0.0436	0.0481	0.0292	0.0367
Lima	0.113	0.118	0.102	0.0940	0.106
Chacaltaya	0.0752	0.0699	0.0618	0.0561	0.0650
Antofagasta	0.0818	0.112	0.0796	0.0736	0.0760
Santiago	0.106	0.0682	0.0923	0.0700	0.0862
Puerto Montt	0.0647	0.0557	0.0335	0.0244	0.0431
Punta Arenas	0.0364	0.0277	0.0139	0.0161	0.0231
Additional U.S. Sites:					
Westwood	0.368	0.315	0.288	0.150	0.271
Chattanooga	0.470	0.476	0.476	0.248	0.410
Appleton	0.236	0.233	0.184	0.188	0.209
Midwest City	0.235	0.303	0.121	0.204	0.214
Palo Alto	0.195	0.323	0.306	lost	0.272
Seattle	0.152	0.398	0.096	0.111	0.189

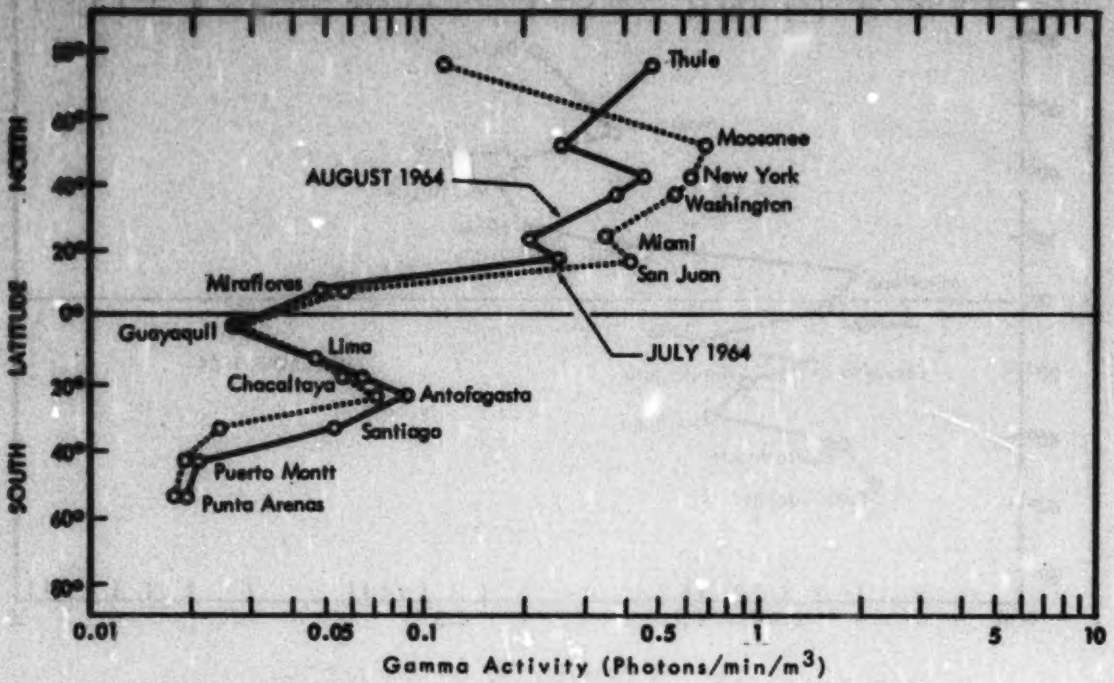

FIGURE 2.—PROFILE OF SURFACE AIR GAMMA ACTIVITY, 80TH MERIDIAN STATIONS, JULY AND AUGUST 1964

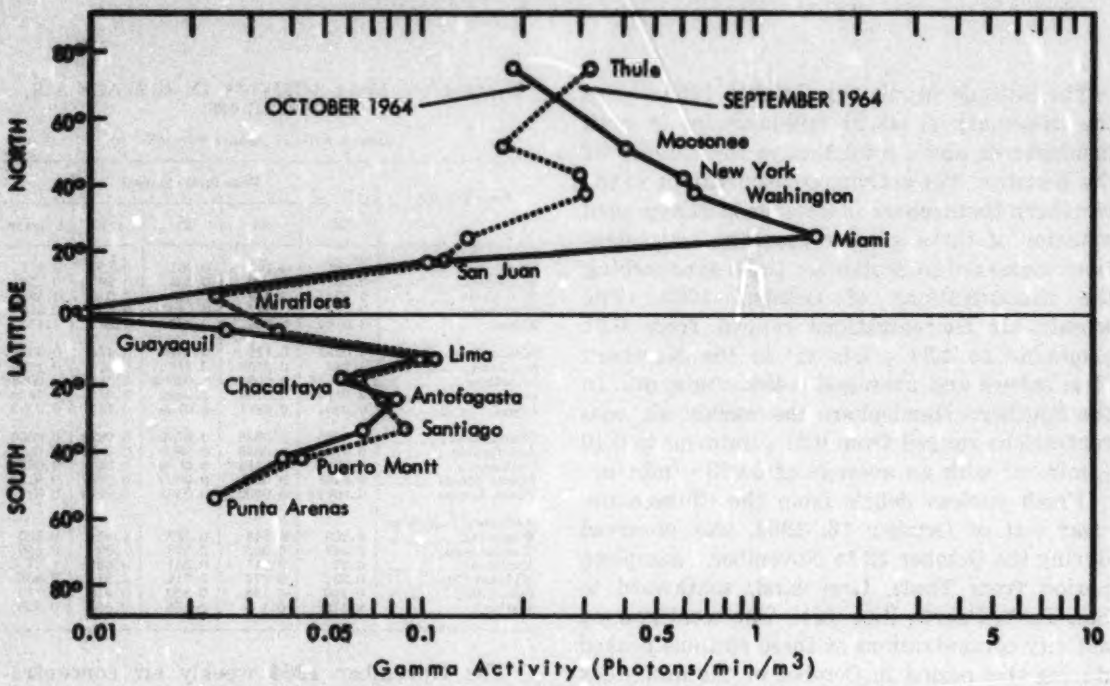

FIGURE 3.—PROFILE OF SURFACE AIR GAMMA ACTIVITY, 80TH MERIDIAN STATIONS, SEPTEMBER AND OCTOBER 1964

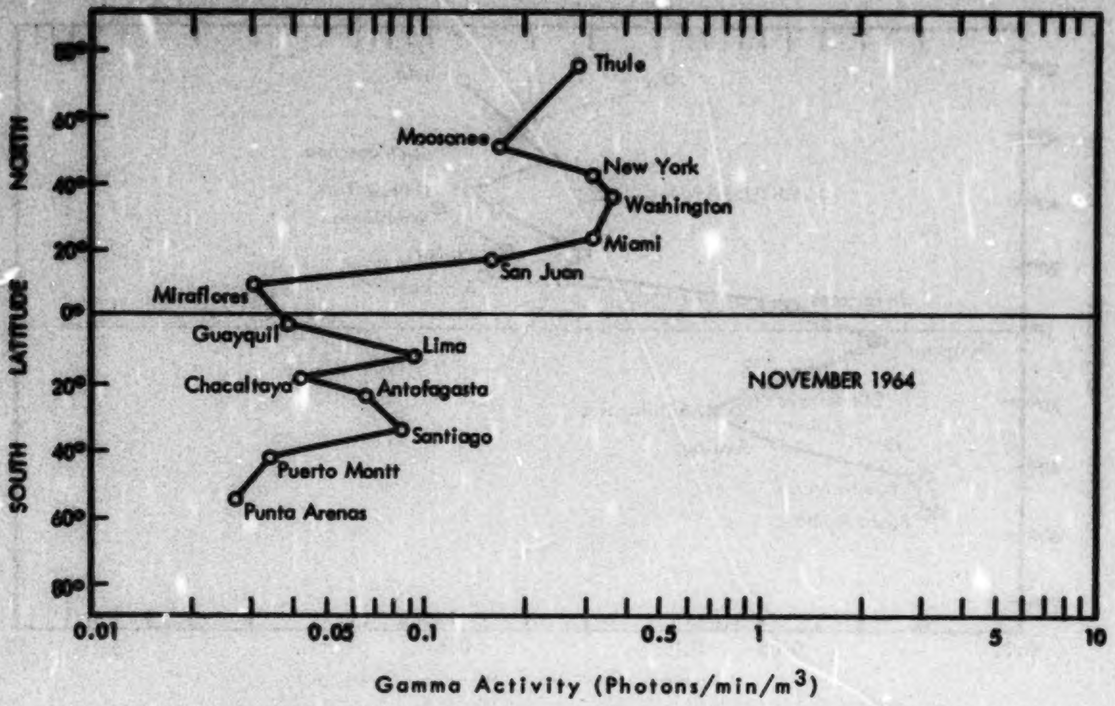

FIGURE 4.—PROFILE OF SURFACE AIR GAMMA ACTIVITY, 80TH MERIDIAN STATIONS, NOVEMBER 1964

The latitude profile for October 1964 shows the customary peaks at mid-latitudes in both hemispheres and a minimum in the vicinity of the Equator. The activity concentrations in the Northern Hemisphere in October 1964 averaged a factor of three greater than the concentrations measured in September 1964, approaching the concentrations of October 1963. The weekly air concentrations ranged from 0.01 γ/min/m³ to 4.34 γ/min/m³ in the Northern Hemisphere and averaged 0.455 γ/min/m³. In the Southern Hemisphere the weekly air concentrations ranged from 0.01 γ/min/m³ to 0.10 γ/min/m³ with an average of 0.063 γ/min/m³.

Fresh nuclear debris from the Chinese nuclear test of October 16, 1964, was observed during the October 22 to November 1 sampling period from Thule, Greenland, southward to San Juan, Puerto Rico (*2*). The total gamma activity concentrations at these stations peaked during this period in October or the first week in November, and then rapidly diminished with time (table 5).

TABLE 4.—GAMMA ACTIVITY IN SURFACE AIR, OCTOBER 1964

[Gamma activity, photons/min/m³]

Sampling site	Date filter changed				
	8	15	22	1/11	Average
Thule	0.182	0.161	0.201	0.166	0.177
Moosonee	0.141	0.120	0.203	0.996	0.394
New York	0.184	0.272	0.250	2.036	0.591
Washington	0.179	0.225	0.180	0.65	0.615
Miami	0.0969	0.0641	0.225	4.34	1.45
Mauna Loa	0.0517	0.116	0.0380	0.474	0.303
San Juan	0.123	0.0553	0.112	0.109	0.100
Miraflores	0.00638	0.00931	0.00628	0.0120	0.00888
Guayaquil	0.0171	0.0143	0.0256	0.0401	0.0258
Lima	0.0861	0.0871	0.0759	0.135	0.0985
Chacaltaya	0.0365	0.0530	0.0730	0.0630	0.0566
Antofagasta	0.0723	0.0658	0.0819	0.0963	0.0810
Santiago	0.0774	0.0556	0.0730	0.0510	0.0652
Puerto Montt	0.0443	0.0200	0.0603	0.0282	0.0375
Punta Arenas	0.00765	0.0202	0.0502	0.0170	0.0231
Additional U.S. Sites:					
Westwood	0.206	0.248	0.177	1.45	0.625
Chattanooga	0.147	0.323	0.238	1.32	0.550
Appleton	0.232	0.217	0.331	3.68	1.27
Midwest City	0.232	0.273	0.314	2.01	0.836
Palo Alto	0.160	0.138	0.300	0.415	0.119
Seattle	0.179	0.155	0.155	0.665	0.299

The November 1964 weekly air concentrations in the Northern Hemisphere ranged from 0.02 to 1.22 γ/min/m³ and averaged 0.210

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γ/min/m³. In the Southern Hemisphere a range of 0.02 to 0.120 γ/min/m³ was observed, with an average of 0.0555 γ/min/m³.

Table 5.—GAMMA ACTIVITY IN SURFACE AIR, NOVEMBER 1964

[Gamma activity, photons/min/m³]

Sampling site	Date filter changed				
	8	15	23	12/1	Average
Thule	0.461	0.316	0.258	0.136	0.284
Moosonee	0.272	0.182	0.134	0.108	0.165
New York	0.436	0.360	0.256	0.176	0.308
Washington	0.526	0.305	0.331	0.175	0.348
Miami	0.620	0.345	0.129	0.185	0.313
Mauna Loa	0.0597	0.0721	0.0780	0.0917	0.0718
San Juan	0.208	0.186	0.160	0.0735	0.155
Miraflores	0.0150	0.0202	0.0416	0.0430	0.0310
Guayaquil	0.0512	0.0333	0.0117	0.0516	0.0362
Lima	no sample	0.0751	0.120	0.0864	0.0933
Chacaltaya	0.0367	0.0279	0.0578	0.0478	0.0429
Antofagasta	0.0630	0.0657	0.0677	0.0856	0.0698
Santiago	0.0548	0.107	0.106	0.0747	0.0848
Puerto Montt	0.0224	0.0433	0.0360	0.0428	0.0346
Punta Arenas	0.0166	0.0274	0.0409	0.0340	0.0270
Additional U.S. Sites:					
Westwood	0.491	0.368	0.226	0.152	0.297
Chattanooga	1.22	0.614	0.201	0.222	0.511
Appleton	0.813	0.247	0.219	0.184	0 489
Midwest City	0.915	0.262	0.203	0.0806	0.362
Palo Alto	0.504	0.215	0.130	0.134	0.253
Seattle	0.328	0.200	0.100	0.105	0.184

A comparative plot of the monthly average concentrations in the Northern and Southern Hemispheres is presented in figure 5. It is evident from this figure that a distinct increase in gamma activity occurred in the Northern Hemisphere following the Chinese nuclear test of October 16, 1964, but in the Southern Hemisphere, the average monthly concentration decreased slightly.

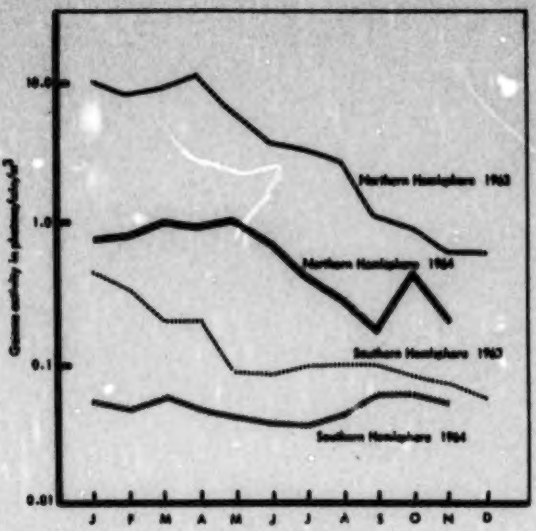

Figure 5.—AVERAGE HEMISPHERIC GAMMA ACTIVITY CONCENTRATIONS FOR 1963 AND 1964

REFERENCES

(1) COLLINS, W. R., JR. Fission product gamma activity in surface air—80th meridian and U.S. locations. Rad Health Data 5:360–362 (August 1964).

(2) HEALTH AND SAFETY LABORATORY. HASL surface air sampling network, gamma activity measurements for October 1964. U.S. Atomic Energy Commission, New York, New York 10014 (February 3, 1965).

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Section II—Milk and Food

MILK SURVEILLANCE

Although milk is only one of the many sources of dietary intake of radionuclides, it is the single food item most often used as an indicator of the population's intake of radionuclides from the environment. This is because fresh milk is consumed by a large segment of the United States population and contains most of the radionuclides occurring in the environment which have been identified as biologically important. In addition, milk is produced and consumed on a regular basis, is convenient to handle, is easily analyzed, and samples representative of milk consumption in any area can be readily obtained.

1. Pasteurized Milk Network
February 1965

Division of Radiological Health and
Division of Environmental Engineering and
Food Protection, Public Health Service

The Public Health Service pasteurized milk surveillance program had its origin in a raw milk monitoring network (*1*) established by the Service in 1957. One of the primary objectives of the raw milk network was the development of methods for milk collection and radiochemical analysis suitable for larger scale programs.

Experience derived from this earlier network led to the activation of a pasteurized milk sampling program with stations selected to provide nationwide surveillance of milk production and consumption areas. The present network, which consists of 63 stations, has at least one station in every State, the Canal Zone, and Puerto Rico.

Sampling procedure

Through the cooperation of State and local milk sanitation authorities, samples are routinely collected at each station. The method specifies that each station's sample be composited of subsamples from each milk processing plant in proportion to the plant's average sales in the community served. At most stations the sample represents from 80 to 100 percent of the milk processed. Prior to September 15, 1961, the composite sample was taken from one day's sales per month and was as representative of the community's supply as could be achieved under practical conditions. Beginning with the resumption of nuclear weapons testing in the atmosphere in September 1961, and continuing through January 1963, samples were collected twice a week at nearly all stations and daily for short periods at selected stations. Since then, the sampling frequency has been reduced to once a week.

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Samples are preserved with formaldehyde and are sent to the PHS Southwestern (SWRHL), Southeastern (SERHL), or Northeastern Radiological Health Laboratories (NERHL) for analysis. Gamma analyses for iodine-131 are made within 3 to 6 days after sample collection, and any results exceeding 100 pCi/liter are immediately telephoned to State health officials for possible public health action. Analytical results are normally available 6 to 7 weeks after monthly samples are received by the laboratories; publication in *RHD* follows 3 to 4 months after the monthly samples are composited for analyses.

Analytical procedures

Iodine-131, cesium-137, and barium-140 concentrations are determined by gamma scintillation spectroscopy.[1] After the weekly samples are gamma scanned, samples from two consecutive weeks are composited and analyzed radiochemically for strontium-89 and strontium-90. There is an inherent statistical variation associated with all measurements of radionuclide concentrations. With the low radionuclide levels which are usually found in milk and other environmental samples, this variation on a percentage basis is relatively high. The variation depends upon such factors as the method of chemical analysis, the sample counting rate and counting time, interferences from other radionuclides, and the background count. For milk samples, counting times of 50 minutes for gamma spectroscopy and 30 to 50 minutes for beta determinations are used. Table 1 shows the approximate total analytical error (including counting error) associated with radionuclide concentrations in milk. These errors were determined by comparing results of a large number of replicate analyses.

The minimum detectable concentration is defined as the measured concentration at which the two-standard deviation analytical error is equal to the measurement. Accordingly, the minimum detectable concentrations in units of pCi/liter are ^{89}Sr, 5; ^{90}Sr, 2; ^{137}Cs, 10; ^{140}Ba, 10; and ^{131}I, 10. At these levels and below the counting error comprises nearly all of the analytical error.

TABLE 1.—ANALYTICAL ERRORS ASSOCIATED WITH ESTIMATED CONCENTRATIONS FOR SELECTED RADIONUCLIDES IN MILK

Nuclide	Estimated concentration (pCi/liter)	Error [a] (pCi/liter)	Estimated concentration (pCi/liter)	Error [a] (percent of concentration)
Iodine-131	0 to 100	±10	100 or greater	±10
Barium-140	0 to 100	±10	100 or greater	±10
Cesium-137	0 to 100	±10	100 or greater	±10
Strontium-89	0 to 50	± 5	50 or greater	±10
Strontium-90	0 to 20	± 2	20 or greater	±10

[a] Two standard deviations (2σ).

Calcium analyses at SERHL are done by an ion exchange and permanganate titration method, while at NERHL and SWRHL an ethylenediaminetetraacetic acid (EDTA) method is used. Stable potassium concentrations are estimated from the potassium-40 concentrations[2] determined from the gamma spectrum.

Data presentation

Table 2 presents summaries of the analyses for February 1965 (actual reporting period is January 31-February 27, 1965). Barium-140 results are not presented because the monthly average concentrations in milk were less than 10 pCi/liter. Radionuclide values reported by a laboratory as being below the minimum detectable concentration have been averaged by using one-half the minimum detectable value. The averaging procedure was modified for iodine-131 and barium-140 in October 1963 when nondetectable concentrations of these radionuclides were considered zero. A similar procedure is used for the network average.

Figures 1 and 2 are isogram maps showing the estimated strontium-90 and cesium-137 concentrations in milk over the entire country. The value printed beside each station is the monthly average concentration for that station. The isograms were developed by arbitrary interpolation between values for the individual stations. Additional modifications to the isograms are made according to available information on milksheds.

The ranges of monthly averages for strontium-90 and cesium-137 at network stations for the last six months and February 1964 are compared in tables 3 and 4. The average

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[1] Southeastern Radiological Health Laboratory employs a radiochemical procedure for barium-140 analysis.

[2] The conversion factor is 1.18 x 10^{-3} g K/pCi ^{40}K.

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TABLE 2.—AVERAGE CONCENTRATIONS OF STABLE ELEMENTS AND RADIONUCLIDES IN PASTEURIZED MILK, FOURTH QUARTER 1964 AND FEBRUARY 1965*

Sampling locations		Calcium (g/liter)		Strontium-89 (pCi/liter)		Strontium-90 (pCi/liter)		Cesium-137 (pCi/liter)		Iodine-131 (pCi/liter)	
		Fourth quarter	Avg. for month	Fourth quarter	Avg. for month	Fourth quarter	Avg. for month	Fourth quarter	Avg. for month	Fourth quarter	Avg. for month
Ala:	Montgomery	1.20	1.20	<5	<5	19	20	60	55	0	0
Alaska:	Palmer	1.22	1.21	<5	<5	19	19	80	55	0	0
Ariz:	Phoenix	1.19	1.22	<5	<5	4	11	25	30	0	0
Ark:	Little Rock	1.17	1.18	<5	<5	32	34	60	65	0	0
Calif:	Sacramento	1.26	1.28	<5	<5	5	7	25	40	0	0
	San Francisco	1.22	1.26	<5	<5	8	5	30	20	0	0
C. Z:	Cristobal	1.14	1.14	<5	<5	5	4	50	35	0	0
Colo:	Denver	1.29	1.25	<5	<5	16	20	65	70	0	0
Conn:	Hartford	1.12	1.14	<5	<5	16	15	85	80	0	0
Del:	Wilmington	1.17	1.16	<5	<5	16	18	70	75	0	0
D. C:	Washington	1.15	1.19	<5	<5	17	16	45	60	0	0
Fla:	Tampa	1.18	1.18	<5	<5	15	13	210	145	0	0
Ga:	Atlanta	1.20	1.20	<5	<5	24	24	85	90	0	0
Hawaii:	Honolulu	1.20	1.21	5	<5	12	12	70	70	0	0
Idaho:	Idaho Falls	1.23	1.16	<5	<5	19	24	90	115	0	0
Ill:	Chicago	1.16	1.12	<5	<5	16	17	75	90	0	0
Ind:	Indianapolis	1.20	1.18	<5	<5	15	18	60	80	0	0
Iowa:	Des Moines	1.22	1.22	<5	<5	21	22	55	70	0	0
Kans:	Wichita	1.26	1.20	<5	<5	17	20	40	60	0	0
Ky:	Louisville	1.16	1.18	<5	<5	23	22	45	60	0	0
La:	New Orleans	1.22	1.26	10	<5	40	44	75	70	0	0
Maine:	Portland	1.18	1.16	<5	<5	24	23	145	140	0	0
Md:	Baltimore	1.16	1.17	<5	<5	18	18	50	65	0	0
Mass:	Boston	1.15	1.18	<5	<5	22	24	125	135	0	0
Mich:	Detroit	1.17	1.17	<5	<5	15	16	75	85	10	0
	Grand Rapids	1.20	1.18	<5	<5	19	19	85	85	0	0
Minn:	Minneapolis	1.24	1.19	5	<5	24	28	80	90	0	0
Miss:	Jackson	1.23	1.26	<5	<5	32	33	60	55	0	0
Mo:	Kansas City	1.22	1.22	<5	<5	21	19	40	60	0	0
	St. Louis	1.24	1.25	<5	<5	18	19	45	80	0	0
Mont:	Helena	1.25	1.28	<5	<5	16	18	85	100	0	0
Nebr:	Omaha	1.19	1.19	<5	<5	17	20	45	50	0	0
Nev:	Las Vegas	1.24	1.07	<5	<5	8	10	30	40	0	0
N. H:	Manchester	1.18	1.16	<5	<5	23	24	155	155	0	0
N. J:	Trenton	1.12	1.12	<5	<5	15	18	70	85	0	0
N. Mex:	Albuquerque	1.23	1.22	<5	<5	9	13	45	40	0	0
N. Y:	Buffalo	1.11	1.10	<5	<5	16	17	90	110	0	0
	New York	1.15	1.12	<5	<5	19	20	95	105	0	0
	Syracuse	1.12	1.10	<5	<5	15	16	90	90	0	0
N. C:	Charlotte	1.21	1.21	<5	<5	32	27	65	65	0	0
N. Dak:	Minot	1.19	1.21	<5	<5	38	49	110	120	0	0
Ohio:	Cincinnati	1.19	1.16	<5	<5	17	16	60	70	0	0
	Cleveland	1.17	1.14	<5	<5	18	18	75	90	0	0
Okla:	Oklahoma City	1.18	1.20	5	<5	18	21	45	55	0	0
Ore:	Portland	1.29	1.27	<5	<5	22	22	90	115	0	0
Pa:	Philadelphia	1.18	1.17	<5	<5	16	18	65	80	0	0
	Pittsburgh	1.18	1.17	<5	<5	34	24	85	100	0	0
P. R:	San Juan	1.14	1.16	<5	<5	10	14	50	55	0	0
R. I:	Providence	1.17	1.16	<5	<5	18	15	95	100	0	0
S. C:	Charleston	1.17	1.20	<5	<5	29	30	90	85	0	0
S. Dak:	Rapid City	1.03	0.94	<5	<5	27	26	115	150	0	0
Tenn:	Chattanooga	1.20	1.21	5	<5	31	30	65	70	0	0
	Memphis	1.20	1.22	<5	<5	25	25	45	45	0	0
Tex:	Austin	1.14	1.16	<5	<5	7	10	25	40	0	0
	Dallas	1.18	1.17	<5	<5	15	17	35	50	0	0
Utah:	Salt Lake City	1.34	1.27	<5	<5	18	33	90	130	0	0
Vt:	Burlington	1.16	1.12	<5	<5	20	20	105	120	10	0
Va:	Norfolk	1.19	1.21	<5	<5	21	19	60	60	0	0
Wash:	Seattle	1.24	1.27	<5	<5	20	28	95	95	0	0
	Spokane	1.30	1.25	<5	<5	22	23	95	100	0	0
W. Va:	Charleston	1.16	1.19	<5	<5	17	16	40	30	0	0
Wis:	Milwaukee	1.22	1.22	<5	<5	14	14	85	100	0	0
Wyo:	Laramie	1.22	1.21	<5	<5	15	16	70	70	0	0
Network average		1.19	1.19	<5	<5	18.8	20.2	73	80	0	0

* Results of barium-140 analysis all zero.

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monthly strontium-90 concentrations in pasteurized milk from selected cities in the sampling program are presented in figure 3. Each graph shows the strontium-90 concentrations in milk from one city in U.S. Bureau of Census regions. This method of selection permits graphic presentation of data for each city in the network three times a year.

For special purposes of comparison and reference, the Network maximum, minimum, and average monthly radionuclide concentrations for the early years of operation (March 1960-March 1964) were summarized in tabular form in the July 1964 *RHD* (*2*). An annual summary for 1964 appeared in the April 1965 *RHD* (*3*).

TABLE 3.—RANGES OF STATION MONTHLY AVERAGES FOR STRONTIUM-90, SEPTEMBER 1964–FEBRUARY 1965, AND FEBRUARY 1964

Range, pCi/liter	Number of stations in range						
	1964				1965		1964
	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Feb.
Under 10	8	6	6	8	6	3	3
10–19	27	37	31	29	32	31	15
20–29	20	13	19	20	19	22	28
30–39	6	7	6	4	4	5	13
40–49	2	0	1	2	1	2	3
50–59	0	0	0	0	1	0	0
60–69	0	0	0	0	0	0	1

TABLE 4.—RANGES OF STATION MONTHLY AVERAGES FOR CESIUM-137, SEPTEMBER 1964–FEBRUARY 1965, AND FEBRUARY 1964

Range, pCi/liter	Number of stations in range						
	1964				1965		1964
	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Feb.
Under 50	14	16	15	9	11	8	1
50–99	33	40	41	38	38	38	14
100–149	13	6	4	14	12	15	24
150–199	2	0	2	2	2	2	17
200–249	1	1	1	0	0	0	5
250–299	0	0	0	0	0	0	2

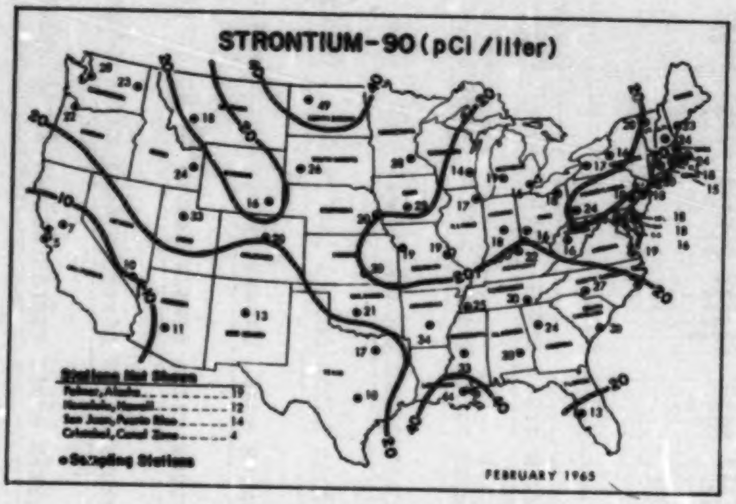
STRONTIUM-90 (pCi/liter)
Stations Not Shown
Palmer, Alaska 19
Honolulu, Hawaii 12
San Juan, Puerto Rico 14
Cristobal, Canal Zone 4
• Sampling Stations
FEBRUARY 1965

FIGURE 1.—STRONTIUM-90 CONCENTRATIONS IN PASTEURIZED MILK, FEBRUARY 1965

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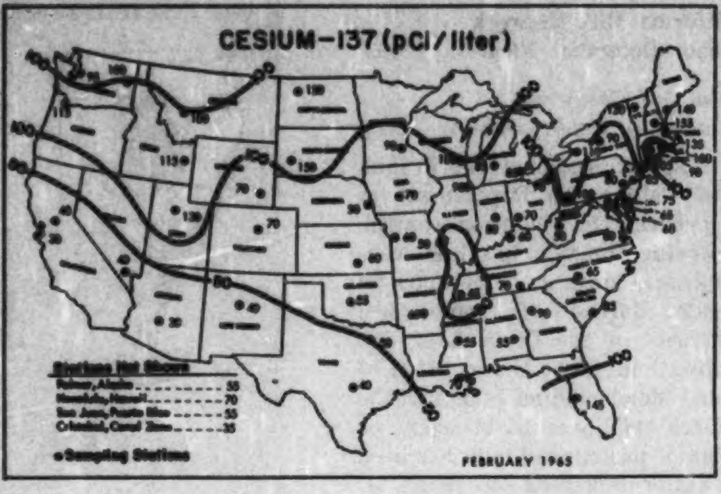
CESIUM-137 (pCi/liter)
Stations Not Shown
Palmer, Alaska 35
Honolulu, Hawaii 70
San Juan, Puerto Rico 35
Cristobal, Canal Zone 35
• Sampling Stations
FEBRUARY 1965

FIGURE 2.—CESIUM-137 CONCENTRATIONS IN PASTEURIZED MILK, FEBRUARY 1965

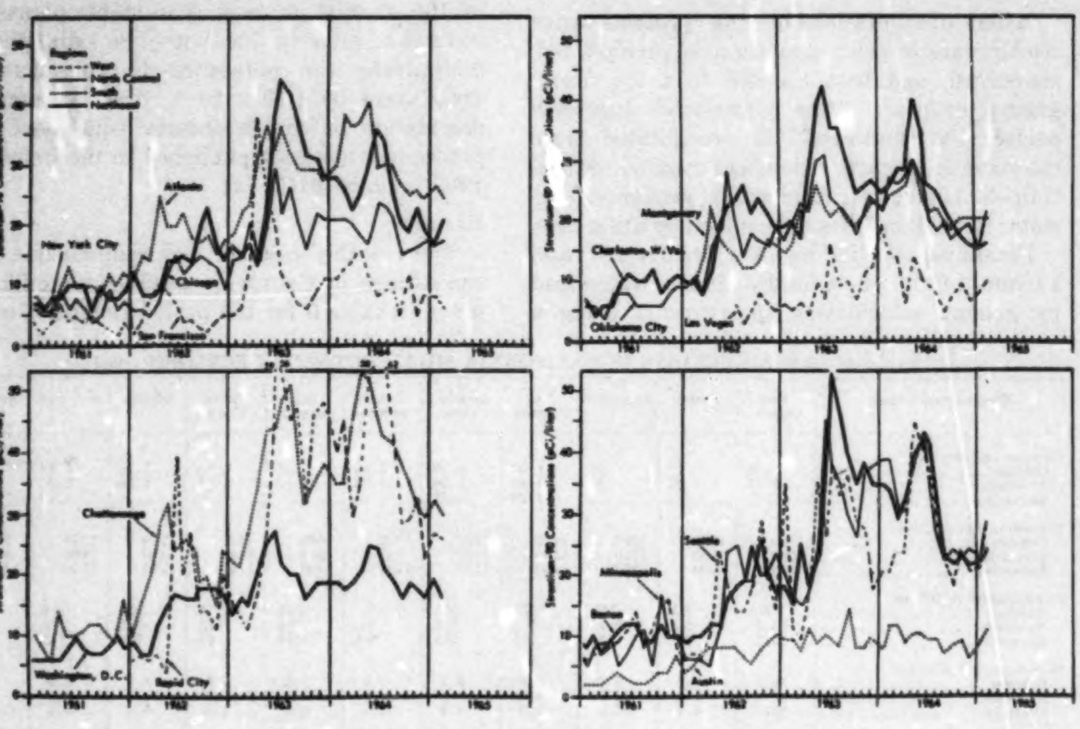

FIGURE 3.—STRONTIUM-90 IN PASTEURIZED MILK, 1961–FEBRUARY 1965

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2. California Milk Network
October–December 1964

State of California
Department of Public Health

Surveillance of specific radionuclides in milk is one phase of California's Department of Public Health program of radiation control. This milk monitoring function has been conducted at 8 milksheds since January 1960 by the Department's Bureau of Radiological Health, a constituent of the Division of Environmental Sanitation. Since the addition of the Del Norte and Mendocino milksheds to the programs in March 1962, weekly, biweekly, or monthly sampling of pasteurized milk has been conducted at 10 major milksheds (see figure 4). The original sampling locations were chosen by the State Department of Agriculture as being representative of milk consumed by a high percentage of the population of the State.

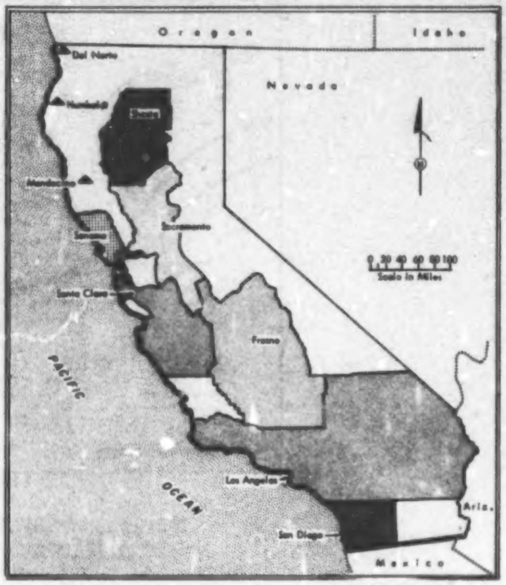

FIGURE 4.—CALIFORNIA MILKSHEDS

Analytical procedures

After precipitation of the proteins with trichloroacetic acid, strontium is precipitated, scavenged, and beta counted in a low background counter. After a two-week ingrowth period, the yttrium–90 is precipitated from the strontium fraction and beta counted. Strontium–90 is determined from the yttrium–90 results; strontium–89 is determined by difference.

Potassium–40, iodine–131, cesium–137 and barium–140 in whole fluid milk are determined by gamma scintillation spectroscopy using a sodium iodide crystal. A normal counting time of 100 minutes is used. The stable potassium content of milk (g/liter) may be estimated by multiplying the potassium–40 concentration (pCi/liter) by 1.18×10^{-3}. A more complete description of the laboratory equipment and procedures has been published in the February 1963 issue of RHD (*3*).

Results

The monthly calcium and radionuclide concentrations in California pasteurized milk are given in table 5 for the period October-Decem-

TABLE 5.—RADIONUCLIDES IN CALIFORNIA MILK,[a] OCTOBER-DECEMBER 1964

Element and month	Del Norte	Fresno	Humboldt	Los Angeles	Mendocino	Sacramento	San Diego	Santa Clara	Shasta	Sonoma	Average
Calcium (g/liter)											
October	1.28	1.18	1.20	1.07	1.10	1.12	1.13	1.10	1.14	1.15	1.15
November	1.33	1.26	1.30	1.16	1.26	1.23	1.17	1.11	1.08	1.36	1.23
December	--------	--------	--------	1.29	1.27	--------	--------	--------	--------	1.19	1.25
Potassium-40 (pCi/liter)											
October	1160	1170	1070	1270	1290	1210	1080	1220	1220	1300	1190
November	1080	1080	1110	1190	1180	992	1200	1140	1170	1280	1142
December	1070	1090	1190	1160	1150	1160	1180	1140	1170	1140	1145
Strontium-89 (pCi/liter)											
October	[b] NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
November	48.5	NA	19.7	NA	NA	NA	NA	NA	NA	NA	6.8
December	53.7	NA	5.8	NA	NA	NA	NA	NA	NA	NA	6.0
Strontium-90 (pCi/liter)											
October	34.7	3.2	8.7	3.6	5.3	4.9	3.5	4.2	6.8	5.9	8.1
November	40.6	4.0	16.2	5.2	11.6	4.7	4.2	4.6	13.9	8.0	11.3
December	35.5	5.4	17.0	6.5	4.3	5.3	6.9	4.0	8.7	7.5	10.1
Cesium-137 (pCi/liter)											
October	67	23	22	12	8	25	16	17	23	7	22
November	129	34	101	37	12	53	24	36	39	43	51
December	173	39	81	38	44	33	25	31	48	36	55

[a] No significant amounts of iodine-131 or barium-lanthanum-140 in samples for this period were found.
[b] NA indicates no analysis.

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ber 1964. As has been noted previously the Del Norte sample differs significantly from the network average. The appearance of strontium-89 in Del Norte and Humboldt Counties was not expected in light of the previous six months' results. The sudden appearance of this radionuclide along with increases in strontium-90 and cesium-137 indicates the influx of fresh fission products during this period. At the present time, field investigations are being conducted to determine the effects of feeding habits upon these values. A description of the various California milksheds was presented earlier by Heslep and Cornish (*4*).

Network average strontium-90 and cesium-137 concentrations are presented graphically in figure 5. Superimposed upon normal seasonal variations is a decreasing trend since the peak which occurred in the spring of 1963. This peak resulted from 1961 and 1962 atmospheric nuclear testing. This downward trend can be expected to continue with the cessation of atmospheric nuclear testing.

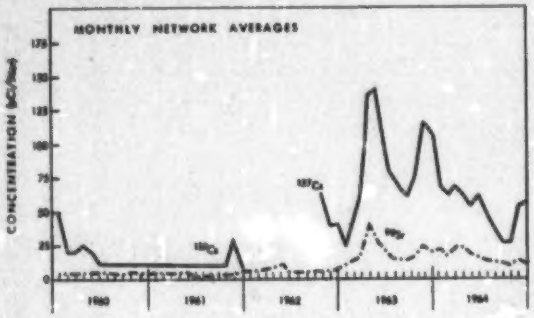

FIGURE 5.—RADIONUCLIDES IN CALIFORNIA PASTEURIZED MILK

Previous coverage in *Radiological Health Data:*

Period	Issue
July–September 1963	*March 1964*
October–December 1963	*June 1964*
January–March 1964	*September 1964*
April–June 1964	*December 1964*
July–September 1964	*March 1965*

3. Oregon Milk Network
October–December 1964

Division of Sanitation & Engineering,
Oregon State Board of Health

The Oregon State Board of Health has monitored the concentrations of radionuclides in milk throughout Oregon on a continuing basis since March 1962. Routinely eight major milk producing areas are sampled, representing 90 percent of the milk distributed in Oregon (see figure 6).

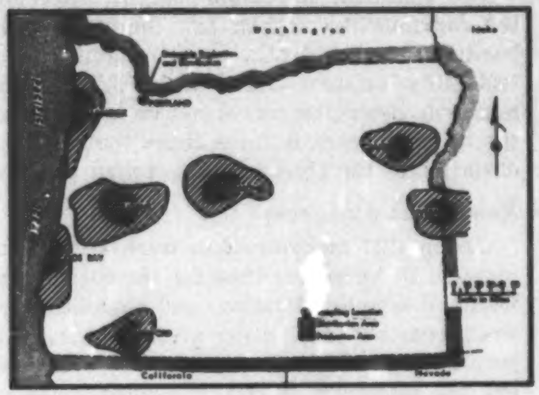

FIGURE 6.—OREGON PASTEURIZED MILK NETWORK SAMPLING LOCATIONS SHOWING PRODUCTION AND DISTRIBUTION AREAS

Half-gallon samples of pasteurized packaged milk are collected monthly from seven milk producing areas statewide by the Oregon State Department of Agriculture. The Portland milk producing area samples are collected weekly by the city of Portland. The Portland milk district sample is also analyzed under the USPHS Milk Surveillance Program on a weekly basis with the results serving as a continuing interlaboratory reference. Milk sampling frequency is accelerated to a weekly basis at those locations where radionuclide concentrations exceed 100 pCi/liter for iodine-131 or 500 pCi/liter for cesium-137. Strontium-90 analyses are currently performed on a bimonthly schedule with a monthly schedule planned when significant increases are observed.

Analytical procedures

All milk samples are forwarded to and analyzed by the Oregon State Board of Health Environmental Radiation Laboratory. The concentrations of cesium–137, iodine–131 and barium–140 are determined by gamma spectrometry using a 3 x 3-inch scintillation detector with a 512-channel analyzer-computer. Strontium–90 concentrations are determined using a trichloroacetic acid analytical procedure (*5*) with the counting performed using a low background counting system with a 2¼-inch detector.

The minimum detectable concentrations for the radionuclides cesium–137, iodine–131 and barium–140 are 15 pCi/liter; the limit of detectability for strontium–90 is 2 pCi/liter. The minimum detectable concentration is defined as the activity which is three times the standard deviation of the observed background activity.

Results and discussion

Cesium–137 concentrations were observed to increase in December 1964 for the coastal and Portland sampling locations and remained relatively constant in all other areas. During this period iodine–131 and barium–140 remained below the minimum detectable concentration of 15 pCi/liter. The October-December 1964 results appear in table 6.

TABLE 6.—RADIONUCLIDE CONCENTRATIONS IN OREGON MILK, OCTOBER-DECEMBER 1964

Sampling location	Concentrations in pCi/liter					
	Strontium-90 1964			Cesium-137 1964		
	Oct	Nov	Dec	Oct	Nov	Dec
Baker	21	36	NA	105	90	65
Coos Bay	[a] NA	NA	NA	90	90	225
Eugene	NA	24	NA	75	85	70
Medford	NA	13	NA	80	80	75
Nyssa	NA	20	NA	55	40	70
Portland composite	22	NA	NA	80	130	112
Portland local	NA	NA	NA	92	90	130
Redmond	NA	NA	NA	105	80	75
Tillamook	36	28	NA	115	145	160
Average	26	24		88	91	109

[a] NA indicates no analysis.

General trends for the levels of strontium–90 and cesium–137 can be observed from the concentrations representing the monthly network averages listed in table 7 and presented graphically in figure 7. The peak concentrations observed during the spring of 1963 have shown a continual decrease, except for seasonal variations. This general trend can be expected to continue with the cessation of atmospheric nuclear testing.

The radionuclide concentrations in Oregon milk have remained low in comparison to the recommendations of the Federal Radiation Council for remedial action based upon health implications.

TABLE 7.—AVERAGE MONTHLY RADIONUCLIDE CONCENTRATIONS IN OREGON MILK

Month and year	Radionuclides	
	Strontium-90	Cesium-137
	pCi/liter	pCi/liter
1962		
July	[a] NA	56
August	NA	63
September	NA	51
October	NA	83
November	NA	86
December	NA	83
1963		
January	NA	68
February	NA	71
March	13	69
April	51	142
May	89	246
June	53	223
July	83	190
August	51	157
September	NA	147
October	NA	139
November	36	174
December	26	173
1964		
January	NA	165
February	20	162
March	25	137
April	36	170
May	36	179
June	26	162
July	26	140
August	24	113
September	20	87
October	26	88
November	24	91
December	NA	109

[a] NA indicates no analysis.

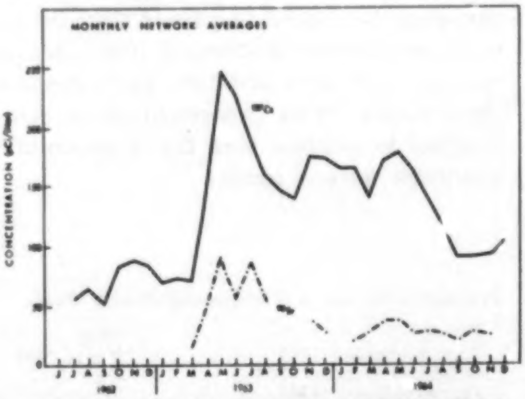

FIGURE 7.—RADIONUCLIDES IN OREGON MILK NETWORK

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4. Pennsylvania Milk Network
October–December 1964

Bureau of Environmental Health,
Pennsylvania Department of Health

Samples of pasteurized milk are routinely collected from ten major milk consumption areas throughout Pennsylvania (figure 8). Two composite samples per week are collected in Philadelphia and Pittsburgh, while weekly composite samples are collected from the other eight stations. At each sampling location subsamples are composited from the major dairies supplying the area. The subsamples are subsequently composited in proportion to the amount of milk processed in each dairy. This composite is then sent to the Radiation Laboratory of the Division of Occupational Health in Harrisburg where the weekly samples are combined for monthly analyses. Strontium–90 analyses have been carried out since April 1963. Iodine–131 analyses were carried out from September 1962 through January 1963, at which time concentrations fell below detectable levels. Iodine–131 analyses were resumed in October 1964 following the mainland China nuclear detonation of October 16.

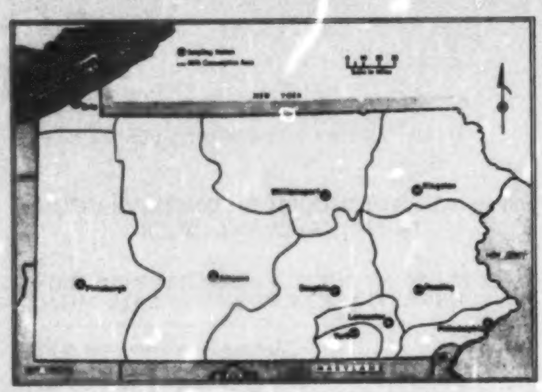

FIGURE 8.—PENNSYLVANIA MILK SAMPLING STATIONS AND MILK CONSUMPTION AREAS

Analytical procedure

The chemical separation technique for strontium–90 is essentially an ion exchange method described by Porter *et al* (*6*). One liter of milk is passed through an ion exchange column; yttrium–90 is eluted from the resin and is counted in an automatic low-background proportional counter.

Iodine–131 is also determined by an ion exchange resin technique (*7*). One liter of milk is passed through an ion exchange column. The exchange resin is subsequently counted and analyzed with a 2 x 2-inch sodium iodide crystal detector and multichannel pulse height analyzer.

Cesium–137 and potassium–40 concentrations are determined by gamma scintillation spectroscopy. The resultant gamma spectra are processed using a matrix system of analysis.

Results and discussion

For the period of October 1964 to December 1964 the results of the Pennsylvania milk network are given in tables 8–11. Potassium–40, strontium–90, cesium–137, and iodine–131 concentrations are presented by sampling station.

The monthly network radionuclide concentrations to date are shown in table 12, and presented graphically in figure 9.

TABLE 8.—POTASSIUM-40 CONCENTRATIONS IN PENNSYLVANIA MILK, OCTOBER–DECEMBER 1964

Sampling location	Potassium-40, pCi/liter		
	October	November	December
Altoona	[a] NA	1047	1033
Dauphin	1103	1014	1166
Erie	NA	1252	936
Kingston	NA	983	958
Lancaster	970	972	964
Philadelphia	NA	1023	1073
Pittsburgh	1048	1032	1092
Reading	1011	1022	1112
Williamsport	NA	1162	984
York	1031	1123	1096
State average	1033	1068	1041

[a] NA indicates no analysis performed.

TABLE 9.—STRONTIUM-90 CONCENTRATIONS IN PENNSYLVANIA MILK, OCTOBER–DECEMBER 1964

Sampling location	Strontium-90, pCi/liter		
	October	November	December
Altoona	20	17	34
Dauphin	24	24	16
Erie	23	29	21
Kingston	16	26	21
Lancaster	12	14	23
Philadelphia	17	25	28
Pittsburgh	28	27	27
Reading	14	18	30
Williamsport	19	16	20
York	12	14	20
State average	18.5	21.0	24.0

TABLE 10.—CESIUM-137 CONCENTRATIONS IN PENNSYLVANIA MILK, OCTOBER–DECEMBER 1964

Sampling location	Cesium-137, pCi/liter		
	October	November	December
Altoona	[a] NA	81	110
Dauphin	88	90	106
Erie	NA	113	117
Kingston	NA	111	115
Lancaster	76	70	89
Philadelphia	NA	95	94
Pittsburgh	73	96	120
Reading	101	77	120
Williamsport	NA	103	101
York	88	81	98
State average	85	92	107

[a] NA indicates no analysis performed.

TABLE 11.—IODINE-131 CONCENTRATIONS IN PENNSYLVANIA MILK, OCTOBER–DECEMBER 1964

Sampling location	Iodine-131, pCi/liter		
	October	November	December
Altoona	[a] NA	20	14
Dauphin	19	18	18
Erie	NA	23	16
Kingston	NA	13	15
Lancaster	54	16	10
Philadelphia	NA	10	10
Pittsburgh	<10	34	11
Reading	47	10	10
Williamsport	NA	27	30
York	<10	11	<10
State average	28	19	14

[a] NA indicates no analysis performed.

The expected seasonal variations are noted to reflect a decreasing trend since the atmospheric nuclear test ban treaty. An increase is noted as a result of the Chinese nuclear detonation of October 16, 1964, during the latter part of 1964. In the spring the iodine-131 concentration can be expected to decrease, accompanied by normal seasonal variation in strontium-90 and cesium-137 concentrations. The observed radionuclide concentrations can be compared with the Federal Radiation Council guides for peacetime operation indicating that at no time during 1964 did the radionuclide concentrations in Pennsylvania milk reach levels such that remedial actions were suggested on the basis of health implications.

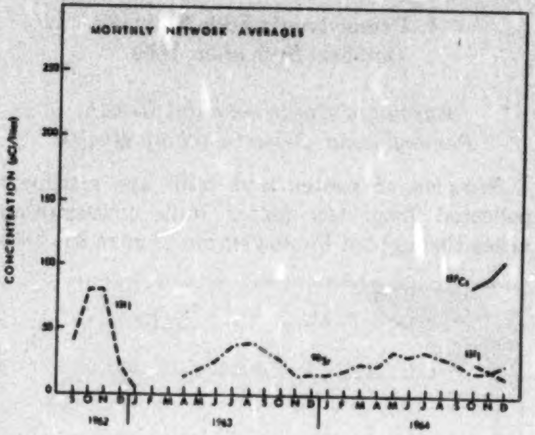

FIGURE 9.—RADIONUCLIDE CONCENTRATIONS IN PENNSYLVANIA MILK

TABLE 12.—MONTHLY AVERAGE RADIONUCLIDE CONCENTRATIONS IN PENNSYLVANIA MILK

Month and year	Radionuclide concentrations, pCi/liter			
	^{40}K	^{90}Sr	^{137}Cs	^{131}I
1962				
September	[a] NA	NA	NA	41.2
October	NA	NA	NA	80
November	NA	NA	NA	80.6
December	NA	NA	NA	24.4
1963				
January	NA	NA	NA	<10
February	NA	NA	NA	NA
March	NA	NA	NA	NA
April	NA	13.5	NA	NA
May	NA	19.7	NA	NA
June	NA	25.1	NA	NA
July	NA	35.5	NA	NA
August	NA	38.6	NA	NA
September	NA	32.0	NA	NA
October	NA	25.4	NA	NA
November	NA	14.7	NA	NA
December	NA	16.7	NA	NA
1964				
January	NA	15.5	NA	NA
February	NA	18.5	NA	NA
March	1563	22.6	137	NA
April	NA	18.9	NA	NA
May	NA	33.9	NA	NA
June	NA	29.8	NA	NA
July	NA	32.6	NA	NA
August	NA	28.5	NA	NA
September	NA	25.0	NA	NA
October	1033	18.5	85	28
November	1068	21.0	92	19
December	1041	24.0	107	14

[a] NA indicates no analysis performed.

Previous coverage in *Radiological Health Data:*

Period	Issue
September 1962–November 1963	*March 1964*
December 1963–March 1964	*July 1964*
April–June 1964	*October 1964*
August–September 1964	*February 1965*

5. Texas Milk Network
April–December 1964

Texas State Department of Health

The Texas State Department of Health initiated a Statewide milk sampling network for radionuclide content in April 1964. At present, monthly samples of raw milk are collected from each of six "active" sampling points. In addition, six "stand-by" stations have been supplied sample containers and shipping instructions and can be activated immediately if needed. The "active" and "stand-by" station locations, shown in figure 10, were chosen to give maximum geographical and population coverage. The monthly grab samples are taken from tank trucks at the processing plants.

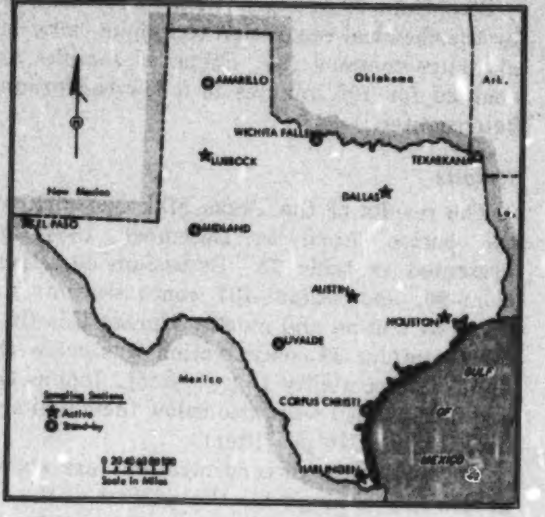

FIGURE 10.—TEXAS MILK SAMPLING STATIONS

Analytical methods

Samples are routinely analyzed for iodine–131, barium–140, cesium–137, potassium–40, strontium–89, and strontium–90. The gamma-emitting radionuclides are analyzed using a 4 x 4-inch sodium iodide crystal and a 400-channel analyzer. Samples are counted for 100 minutes in a 3½-liter Marinelli beaker. The matrix method of calculation is used and detectable limits at the 95 percent confidence level are 10 pCi/liter. Calcium determinations are not made.

TABLE 13.—RADIONUCLIDE CONCENTRATIONS IN TEXAS MILK NETWORK, APRIL TO DECEMBER 1964

Sampling location	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
	Potassium-40 (pCi/liter)								
Austin	1260	1230	1250	1290	NA	1180	1280	1320	1340
Dallas	ª NA	NA	NA	1280	1330	1290	1270	1270	1310
El Paso	1255	1270	1230	1285	1250	1290	1200	1340	1360
Harlingen	1255	1320	1270	1320	1230	1190	1280	1360	1410
Houston	1255	1320	1290	1320	1260	1300	1300	1380	1390
Lubbock	1240	1265	1215	1245	1230	1260	1210	1330	1350
Average	1253	1280	1251	1290	1264	1252	1267	1333	1358
	Strontium-90 (pCi/liter)								
Austin	10	10	9	11	NA	7	6	7	8
Dallas	ª NA	NA	NA	10	NA	NA	10	8	8
El Paso	12	5	5	8	6	4	3	4	5
Harlingen	10	9	8	6	6	10	4	5	5
Houston	17	22	19	16	13	14	14	10	11
Lubbock	8	12	10	11	6	7	6	7	5
Average	11	12	10	9	8	10	7	7	7
	Cesium-137 (pCi/liter)								
Austin	35	40	40	55	NA	35	30	15	25
Dallas	ª NA	NA	NA	35	30	35	20	30	30
El Paso	35	20	25	25	30	25	15	15	25
Harlingen	30	25	25	30	20	25	25	20	20
Houston	90	80	65	65	55	45	35	40	50
Lubbock	30	35	30	30	30	20	20	20	30
Average	44	40	30	40	33	31	24	23	30

ª NA—No analysis performed.

Strontium-89 and strontium-90 are analyzed by the chemical separation technique using ion exchange columns (*6*). Prepared samples are counted for 100 minutes in a low-background beta counter.

Results

The results of the Texas Milk Network for the period April to December 1964 are presented in table 13. Potassium-40, strontium-90, and cesium-137 concentrations are given by station and month. During this time, the strontium-89 concentration was below the limit of detectability (5 pCi/liter). Iodine-131 and barium-140 were also below their limits of detectability (10 pCi/liter).

Network average concentrations are shown graphically in figure 11. Comparison of the observed radionuclide concentrations with the Federal Radiation Council guides for peacetime operation indicates that at no time during the period of surveillance did the radionuclide concentrations in Texas milk approach such levels that remedial action was suggested based on health implications.

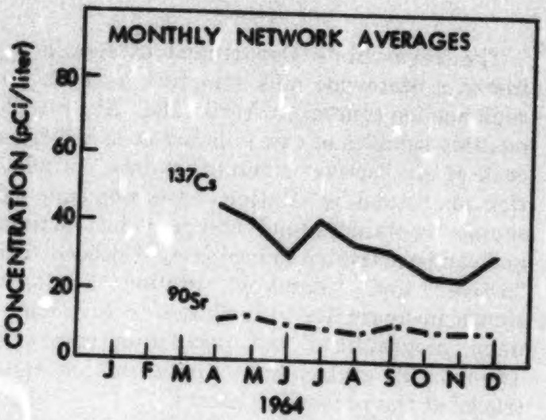

FIGURE 11.—RADIONUCLIDE CONCENTRATIONS IN TEXAS MILK NETWORK

6. Canadian Milk Network[3]
February 1965

Radiation Protection Division, Department of National Health and Welfare, Ottawa, Canada

The Radiation Protection Division of the Department of National Health and Welfare began monitoring milk for strontium-90 in November 1955. At first, analyses were carried out on samples of powdered milk obtained from processing plants. However, since January 1963 liquid whole milk has been analyzed instead. With this change, more representative samples of milk consumed can be obtained, and in addition it is possible to choose milk sampling locations (see figure 12) in the same areas as the air and precipitation stations. At present, the analyses include determinations of iodine-131, strontium-89, cesium-137, and strontium-90 as well as stable potassium and calcium.

The milk samples are obtained through the cooperation of the Marketing Division of the Canadian Department of Agriculture. At each station samples are collected three times a week from selected dairies and are combined into weekly composites and forwarded to the radiochemical laboratory in Ottawa. The contribution of each dairy to the composite sample is directly proportional to its volume of sales. In most cases a complete sample represents over 80 percent of the milk processed and distributed in the area. Several of the weekly samples are randomly selected and analyzed for iodine-131. The results of the spot checks for iodine-131 will not be reported unless there is evidence that the levels are rising. A monthly composite of the samples is analyzed for strontium-90, cesium-137, and stable potassium and calcium.

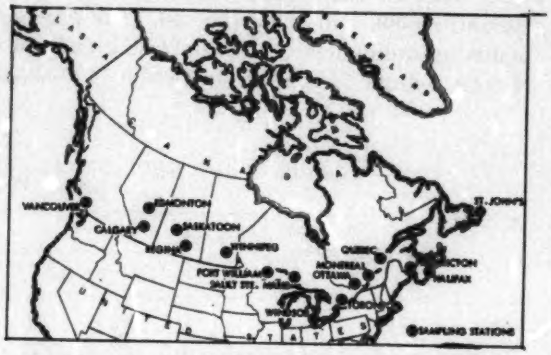

FIGURE 12.—CANADIAN MILK SAMPLING STATIONS

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[3] Data from *Radiation Protection Programs*, Vol. 3, No. 3: 25-30. Radiation Protection Division, Canadian Department of National Health and Welfare (March 1965).

Analytical methods

Radiochemical methods are used for the analysis of iodine–131 (*8*). For the analysis of radiostrontium, carrier strontium is added to a one-liter sample of milk, and the milk is then placed in a tray lined with a polyethylene sheet and evaporated under infrared lamps. The residue is ashed in a muffle furnace at 450 degrees C., dissolved in dilute nitric acid, and strontium separated by fuming nitric acid precipitation. The combined strontium–89 and strontium–90 are determined by counting in a low-background beta counter. Strontium–90 is determined separately by extracting and counting its yttrium–90 daughter, while strontium–89 is estimated by difference from the total radiostrontium measurement. Appropriate corrections are made for self-absorption and counter efficiency at all stages. Calcium is determined by flame photometry.

Cesium–137 is determined by gamma spectroscopy using a scintillation crystal and a multi-channel pulse-height analyzer. A sample consisting of 4.5 liters of milk is placed in a sample tray constructed in the form of an inverted well to accommodate the 5 x 4-inch sodium-iodide crystal detector. The sample is counted for 100 minutes and the gamma spectrum recorded. Estimates are made of the potassium–40 and cesium–137 content of the milk by comparison of the spectrum with the spectra of standard preparations of these two radionuclides. With this method the potassium–40 concentration is determined and the Compton contribution of this radionuclide to the cesium–137 photopeak is subtracted to obtain the cesium–137 concentration. The stable potassium content is estimated from the potassium–40 concentration.

Sources of error

In the iodine and strontium determinations, tests indicate that the statistical error (95-percent confidence level) in the chemical operations involved is about plus-or-minus 10 percent. This value is independent of the concentration of the radioisotope in the milk because it depends only on the recovery of the carrier. In the determination of cesium–137 this factor is not involved.

The chemical procedures error must be combined with the counting error which depends primarily on the concentration of the nuclide in the sample, the background radiation, and the length of time the sample and background are counted. This counting error has been evaluated mathematically for the particular counting arrangement used.

The overall errors, estimated on the basis indicated above, are given in table 14.

TABLE 14.—TOTAL ERROR FOR VARIOUS RADIONUCLIDE CONCENTRATIONS IN MILK[a]

Nuclide	Error for 10 pCi/liter	Error for 50 pCi/liter	Error for 100 pCi/liter
Strontium-89	±25%	±20%	±15%
Strontium-90	±15%	±10%	±10%
Iodine-131	±50%	±20%	±10%
Cesium-137	±60%	±20%	±10%

[a] All errors are 2σ values, representing 95 confidence levels.

Results

Table 15 presents February levels of strontium–90, cesium–137, and stable calcium and potassium in Canadian whole milk. Spot checks for iodine–131 and strontium–89 indicate that all samples had insignificant levels of these radionuclides.

The results show that radionuclide concentrations in Canadian whole milk remained well below the levels permissible on health grounds.

TABLE 15.—NUCLIDES IN CANADIAN WHOLE MILK, FEBRUARY 1965

Station	Calcium (g/liter)	Potassium (g/liter)	Strontium-90 (pCi/liter)	Cesium-137 (pCi/liter)
Calgary	1.13	1.6	26.8	120
Edmonton	1.13	1.6	24.8	132
Ft. William	[a]	1.6	41.3	181
Fredericton	1.13	1.6	35.4	194
Halifax	1.08	1.6	41.4	252
Montreal	1.06	1.6	28.5	157
Ottawa	1.06	1.6	23.0	122
Quebec	1.08	1.7	30.4	228
Regina	1.08	1.7	33.2	157
St. John's, Nfld	1.00	1.5	30.8	176
Saskatoon	1.10	1.6	28.7	111
Sault Ste. Marie	1.00	1.7	32.5	193
Toronto	1.06	1.6	13.5	93
Vancouver	1.15	1.6	39.4	265
Windsor	1.10	1.6	16.3	90
Winnipeg	1.01	1.6	29.5	152
Average	1.08	1.6	30.3	164

[a] No analysis reported.

7. Pan American Milk Sampling Program February 1965

Pan American Health Organization and *Public Health Service*

In accordance with a joint agreement, the PAHO (Pan American Health Organization) and the PHS (Public Health Service), developed a collaborative program for furnishing assistance to health authorities in the Americas engaged in developing programs in radiological health.

Under this agreement, the PHS Division of Radiological Health furnishes to PAHO, on a loan basis, limited quantities of essential items of equipment and the requisite laboratory services to establish a surveillance program.

Sampling procedure

Initially, air sampling stations were established in Chile, Jamaica, Peru, and Venezuela. In August 1963 this was expanded to include a milk sampling station in Caracas, Venezuela. Between April 1964 and August 1964, milk stations were added in Jamaica at Kingston, Montego Bay, and Mandeville. Sampling varies according to local procedures.

Under the direction of the Venezuelan Institute for Scientific Investigation, weekly samples are collected, preserved with formaldehyde and composited monthly.

Jamaica, under the direction of the Ministry of Health, collects one monthly composite on a rotating basis from one of the three principal milk areas; Montego Bay (Montpelier), Mandeville, and Kingston (Spanish Town). To reduce spoilage it was necessary to establish cooling stations in the western parishes where the milk is received prior to shipping to the Condensery in Kingston. All samples are sent to the PHS Southeastern Radiological Health Laboratory for analyses.

Analytical procedures

Iodine-131 and cesium-137 are determined by gamma scintillation spectroscopy. Strontium-89, strontium-90, and barium-140 are determined radiochemically. Analytical errors are described in the *Analytical Procedures* discussion of article 1, "Pasteurized Milk Network".

Data presentation

Table 16 presents stable calcium and potassium, strontium-89, strontium-90, and cesium-137 monthly average concentrations. The monthly average of iodine-131 and barium-140 concentrations in milk were less than 10 pCi/liter. For comparison purposes, the radionuclide concentrations at Cristobal, Canal Zone, and San Juan, Puerto Rico are presented.

TABLE 16.—STABLE ELEMENT AND RADIONUCLIDE CONCENTRATIONS IN MILK, PAHO, FEBRUARY 1965

Sampling stations	Calcium	Potassium	Strontium-89	Strontium-90	Cesium-137
	(g/liter)	(g/liter)	(pCi/liter)	(pCi/liter)	(pCi/liter)
Canal Zone:					
Cristobal	1.14	1.6	<5	4	35
Jamaica:					
Kingston	[a] NS	NS	NS	NS	NS
Mandeville	NS	NS	NS	NS	NS
Montego Bay	1.24	1.32	<5	20	485
Puerto Rico:					
San Juan	1.16	1.5	<5	14	55
Venezuela:					
Caracas	1.17	1.34	<5	10	25

[a] NS indicates no sample collected during this period.

8. Radiostrontium in Milk[4]
January–December 1964

Health and Safety Laboratory
U.S. Atomic Energy Commission

In 1954 the Health and Safety Laboratory began strontium–90 monitoring of liquid whole milk in New York City to estimate the dietary contribution from ingestion of radiostrontium in milk. Subsequently, powdered milk monitoring was initiated at Perry, New York (1954) and at Mandan, North Dakota (1955). Liquid whole milk monitoring was started in Honolulu, Hawaii, in August 1959.

The New York City sample is a monthly composite of pasteurized milk purchased daily in quart containers at retail stores. Five large dairies are represented in the sample. The Honolulu samples are monthly composites of quart samples of pasteurized milk collected weekly. Samples from two dairies are analyzed and the results are averaged. The Mandan and Perry samples are monthly composites of powdered milk collected in 5-pound lots from plants in each city. The Mandan sample is powdered buttermilk used in cattle feeds. Because of its protein and fat content, this buttermilk powder is used primarily as a milk replacer or feed supplement for calves. The Perry sample is powdered whole milk used for human consumption. The source of the Honolulu milk is a herd on the island of Oahu where the cows are on pasture throughout the year.

The calcium and strontium–90 data are presented in tables 17–19. The fluctuations of strontium–90 with time are shown in figures 13 and 14.

Discussion

The increase in strontium–90 concentrations in liquid whole milk noted in 1963 was followed by a decreasing trend throughout 1964. A seasonal variation with the traditional spring peak in strontium–90 concentration was observed. The Honolulu, Hawaii, concentrations continued to remain below those of the other sampling stations.

TABLE 17. STRONTIUM-90 AND CALCIUM IN LIQUID MILK, JANUARY–DECEMBER 1964

Sampling station and month	Calcium concentration (g/liter)	Strontium-90 concentration (pCi/liter)	Strontium-90/calcium ratio (pCi/g Ca)
New York City			
1964			
January	1.04	22.0	21.1
February	1.08	25.8	23.9
March	1.03	28.1	27.2
April	1.03	26.9	26.1
May	1.04	31.9	30.6
June	1.00	30.9	30.9
July	0.99	21.8	22.0
August	0.96	23.9	24.9
September	1.04	17.8	17.1
October	1.04	15.4	14.8
November	1.04	20.4	19.7
December	1.04	20.1	19.3
Honolulu, Hawaii			
1964			
January	1.09	8.5	7.8
February	1.15	9.4	8.2
March	1.10	11.8	10.7
April	1.08	10.5	9.8
May	1.06	10.9	10.3
June	1.08	12.0	11.2
July	1.05	10.2	9.7
August	1.02	6.8	6.6
September	1.04	7.7	7.4
October	1.05	7.2	6.8
November	1.03	8.0	7.8
December	1.04	8.0	7.6

TABLE 18.—STRONTIUM-90 AND CALCIUM IN POWDERED MILK, JANUARY–DECEMBER 1964

Sampling station and month	Calcium concentration (g/kg)	Strontium-90 concentration (pCi/kg)	Strontium-90/calcium ratio (pCi/g Ca)
Perry, New York			
1964			
January	8.63	174	20.1
February	8.79	191	21.7
March	9.29	194	20.9
April	8.69	183	21.0
May	8.84	171	19.3
June	8.57	210	24.5
July	8.67	243	28.0
August	8.63	191	22.1
September	8.67	163	18.8
October	8.92	143	16.0
November	8.54	126	14.7
December	8.80	159	18.0

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[4] Data summarized from Health and Safety Laboratory, AEC, Fallout Program Quarterly Summary Report, HASL–155: 199–207, Office of Technical Services, Department of Commerce, Washington, D.C. 20230 (January 1, 1965).

TABLE 19.—STRONTIUM-90 AND CALCIUM IN POWDERED BUTTERMILK, JANUARY-DECEMBER 1964

Sampling station and month	Calcium concentration (g/kg)	Strontium-90 concentration (pCi/kg)	Strontium-90/ calcium ratio (pCi/g Ca)
Mandan, North Dakota			
1964			
January	10.8	738	68.3
February	10.0	520	51.8
March	11.3	830	73.2
April	11.5	936	81.2
May	12.1	1207	100.0
June	12.5	844	67.5
July	12.6	564	44.8
August	11.8	411	34.8
September	12.0	494	41.0
October	14.9	748	50.0
November	11.5	610	53.0
December	10.6	602	56.8

The powdered milk and buttermilk samples also displayed a downward trend in strontium-90 concentration since the 1963 peak which followed 1961 and 1962 atmospheric nuclear testing.

It is interesting to note that approximately 0.1 kg of powdered milk is used to prepare 1 liter of liquid milk. If this value is used, strontium-90 concentrations in powdered milk are comparable to those in liquid whole milk.

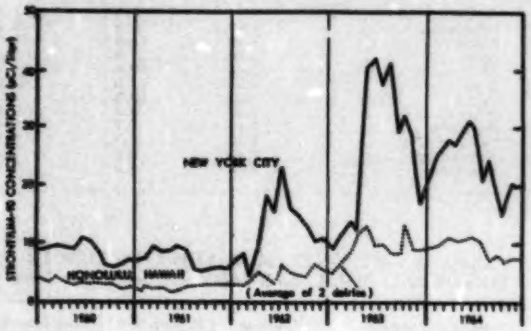

FIGURE 13.—STRONTIUM-90 IN LIQUID MILK SAMPLES

Recent coverage in *Radiological Health Data:*

Period	Issue
October 1962–March 1963	*October 1963*
April–June 1963	*January 1964*
July–September 1963	*April 1964*
October–December 1963	*July 1964*

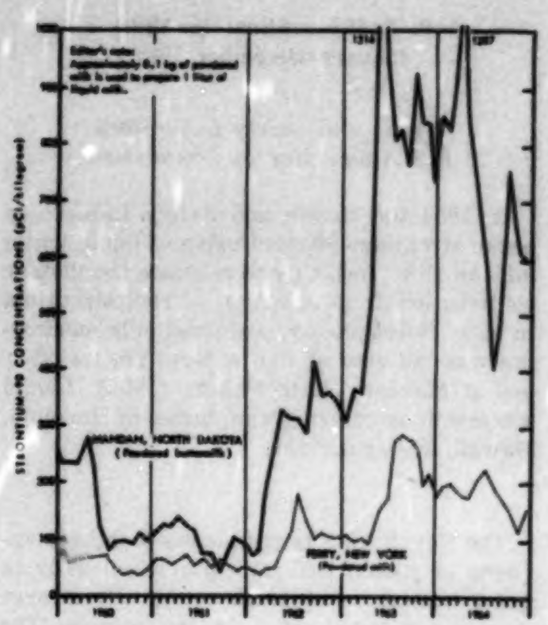

FIGURE 14.—STRONTIUM-90 IN POWDERED MILK SAMPLES

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APPLICATION OF RADIONUCLIDE CONCENTRATIONS IN MILK TO INTAKE GUIDES, MARCH 1964–FEBRUARY 1965

Division of Radiological Health, Public Health Service

The concentrations of specific radionuclides in milk analyzed as part of the Pasteurized Milk Network (PMN) are reported on a monthly basis in *RHD*. In terms of radiological health surveillance activities, an important aspect of these data is the estimation of resultant radiation dose to population groups.

Approximate relationships between certain radionuclide intakes and dose have been applied to the formulation of daily intake guides (*1*) and permissible concentrations in selected environmental media (*2*). Although these guides are not themselves directly applicable to worldwide fallout, a comparison with environmental contamination levels does yield a measure of population dosage. In general, intake-dose and dose-biological effect relationships used in formulating the guides cited are based on continuous intake over an entire lifetime. However, for general surveillance purposes, yearly average intakes, used with discretion, may be compared directly with the levels adopted as lifetime intake guides. Thus, the radionuclide concentrations in milk, averaged over a year's time, together with milk consumption data, might be used in conjunction with the references cited above to approximate the radiation dose to a specific population group from a specific radionuclide. Table 1 presents annual averages of radionuclide concentrations in milk sampled by the *PMN*. Limited data are available for estimating the average daily milk consumption (on a volume basis) for specific age groups in the U.S. population (*3, 4*).

Total dietary intake is of prime interest, and since the intake via milk consumption constitutes only a portion of the total radionuclide intake, the relationship of milk intake to total dietary intake is of importance in evaluating milk surveillance data. The Federal Radiation Council (*5*) notes: "A number of studies have shown that conservative estimates of the strontium–90 to calcium ratio in the total diet may be made by multiplying the ratio of strontium–90 to calcium in milk in a particular locality by 1.5."[1] Thus, a rough index of the total dietary intake of strontium–90 on an annual basis may be made from PMN annual averages by using this factor and the assumptions of approximately 1.2 g of calcium per liter in PMN samples and 1.0 g daily intake of calcium.

In the case of iodine–131, milk can be considered the major source because of the rapid distribution and consumption of fresh milk. With most other foods, normal processing and distribution allows time for the radioactive decay of this short-lived nuclide to insignificant levels.

The situation with respect to strontium–89 is more complicated. Its half-life of some 50 days makes it difficult to estimate the relative contribution made by sources other than milk to the total dietary intake.

The relative contribution of milk to the total dietary intake of cesium–137 is not well defined and depends principally on the amount of freshly deposited cesium–137 on products used for human and animal consumption, and the progress of cesium–137 through the food chain.

The data in table 1 are calculated as follows: results from all samples collected in each week (Sunday through Saturday) are averaged, and

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[1] This ratio may vary from 1 to 2, depending on changes in rate of fallout deposition and relative consumption of non-milk products whose contamination reflect temporal and local deposition patterns (*6*).

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TABLE 1.—AVERAGE RADIONUCLIDE CONCENTRATIONS IN MILK, FOR THE TWELVE MONTH PERIODS FEBRUARY 1964–JANUARY 1965[a] AND MARCH 1964–FEBRUARY 1965[b]

Sampling locations		Average radionuclide concentrations, pCi/liter							
		Strontium-89		Strontium-90		Iodine-131		Cesium-137	
		Feb 1964–Jan 1965	Mar 1964–Feb 1965	Feb 1964–Jan 1965	Mar 1964–Feb 1965	Feb 1964–Jan 1965	Mar 1964–Feb 1965	Feb 1964–Jan 1965	Mar 1964–Feb 1965
Ala:	Montgomery	3	3	22	22	0	0	76	71
Alaska:	Palmer	5	4	30	30	0	0	115	105
Ariz:	Phoenix	3	3	4	5	0	0	35	36
Ark:	Little Rock	3	3	43	42	1	1	110	101
Calif:	Sacramento	3	3	7	7	0	0	40	38
	San Francisco	3	3	10	9	0	0	44	40
C. Z:	Cristobal	3	3	5	5	0	0	50	49
Colo:	Denver	3	3	19	19	0	0	85	83
Conn:	Hartford	3	3	19	19	0	0	127	120
Del:	Wilmington	3	3	22	22	1	1	108	101
D. C:	Washington	3	3	19	19	0	0	73	71
Fla:	Tampa	3	3	15	15	0	0	229	227
Ga:	Atlanta	3	3	31	29	0	0	125	119
Hawaii:	Honolulu	3	3	12	12	0	0	76	76
Idaho:	Idaho Falls	4	4	25	24	0	0	146	135
Ill:	Chicago	3	3	18	18	0	0	104	99
Ind:	Indianapolis	3	3	19	19	1	1	87	83
Iowa:	Des Moines	4	4	24	24	0	0	78	75
Kans:	Wichita	4	4	20	20	0	0	60	58
Ky:	Louisville	3	3	29	28	0	0	76	70
La:	New Orleans	3	3	49	49	0	0	127	120
Maine:	Portland	3	3	28	28	1	1	179	173
Md:	Baltimore	3	3	22	22	0	0	86	81
Mass:	Boston	3	3	30	29	0	0	182	182
Mich:	Detroit	3	3	18	17	2	2	100	96
	Grand Rapids	2	2	20	20	1	1	112	107
Minn:	Minneapolis	6	6	30	29	0	0	127	118
Miss:	Jackson	4	3	40	40	0	0	93	87
Mo:	Kansas City	5	4	26	25	0	0	69	66
	St. Louis	4	4	22	21	0	0	70	66
Mont:	Helena	4	4	24	22	1	1	145	133
Nebr:	Omaha	3	3	24	24	0	0	82	77
Nev:	Las Vegas	3	3	9	9	1	1	66	62
N. H:	Manchester	3	3	29	28	1	1	200	200
N. J:	Trenton	3	3	18	18	1	1	104	99
N. Mex:	Albuquerque	3	3	11	11	1	1	52	50
N. Y:	Buffalo	3	3	19	19	0	0	126	120
	New York	3	3	24	23	1	1	139	132
	Syracuse	[c]3	[d]3	[c]18	[d]18	[c]0	[d]0	[c]122	115
N. C:	Charlotte	3	3	36	36	0	0	101	97
N. Dak:	Minot	10	10	53	52	0	0	144	140
Ohio:	Cincinnati	3	3	21	21	0	0	82	76
	Cleveland	3	3	20	20	0	0	103	100
Okla:	Oklahoma City	3	3	22	21	0	0	62	59
Ore:	Portland	5	5	29	28	0	0	141	139
Pa:	Philadelphia	3	3	19	19	0	0	103	98
	Pittsburgh	3	3	28	28	0	0	133	127
P. R:	San Juan	3	3	12	12	0	0	70	69
R. I:	Providence	3	3	23	22	0	0	143	136
S. C:	Charleston	3	3	22	21	0	0	119	113
S. Dak:	Rapid City	5	5	38	37	0	0	138	135
Tenn:	Chattanooga	4	3	40	39	0	0	105	98
	Memphis	3	3	32	31	0	0	64	61
Tex:	Austin	3	3	9	8	0	0	37	35
	Dallas	3	3	19	19	0	0	55	51
Utah:	Salt Lake City	6	5	24	24	0	0	159	152
Vt:	Burlington	3	3	25	24	2	2	154	147
Va:	Norfolk	3	3	18	18	0	0	85	81
Wash:	Seattle	6	6	26	27	0	0	140	139
	Spokane	5	5	26	25	0	0	128	124
W. Va:	Charleston	3	3	25	24	0	0	68	63
Wis:	Milwaukee	3	3	17	16	1	1	115	110
Wyo:	Laramie	6	6	20	19	0	0	97	95
Network average		4	3	23.1	22.7	0	0	104	100

[a] Annual averages were computed on basis of 53 weekly averages. Annual averages for barium-140 at each station were <10.
[b] Annual averages were computed on basis of 52 weekly averages.
[c] Annual averages were computed on basis of 49 weekly averages. No sample was collected during July 1964.
[d] Annual averages were computed on basis of 48 weekly averages. No sample was collected during July 1964.

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the averages for all weeks terminating in each of twelve consecutive months are averaged to obtain the annual average[2]. To obtain the annual average daily intake (pCi/day) of radionuclides from milk, the annual average concentration values (pCi/liter) in table 1 must be multiplied by the annual average daily consumption (liters/day) of milk.

Monthly variations of radionuclide concentrations in milk are influenced by a number of combined causes such as meteorologic conditions and dairying practices, apart from considerations of original sources of radionuclides. The moving yearly average (table 1) obtained by updating the previous twelve-month average by one month, shows variations averaged over the year and tends to minimize purely seasonal variations.

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[2] Beginning with the October 1963 data, iodine-131 values of <10 pCi/liter have been considered zero for averaging purposes; previously, 5 pCi/liter was used for calculating the averages.

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STRONTIUM-90 IN TRI-CITY DIETS,[1] AUGUST–OCTOBER 1964

Health and Safety Laboratory,
Atomic Energy Commission

Since March 1960, the Health and Safety Laboratory, through its quarterly diet study, has made estimates of the strontium-90 content of the average diet of individuals living in New York City, San Francisco, and Chicago.

Selected foods representing 19 food categories are purchased at each of these three cities about every 3 months and are analyzed for strontium-90. Using data from the U.S. Department of Agriculture (*1*) the annual consumption by an average individual can be grouped into the same 19 food categories. The annual dietary intake of strontium-90 can be estimated by summing the contributions from each category. Some food types are assumed to be representative of larger food categories, such as liquid milk for dairy products in general.

The consumption data (*1*) are based on a weight-as-purchased basis. Before the food samples for the Tri-City Diet Study are ashed for radiochemical analysis, they are prepared to a certain degree as if for actual consumption. For example, fruits are peeled, eggs are shelled, and poultry is boned. Therefore, concentrations of radioactivity in foods as reported in the Tri-City Diet Study are based on the trimmed weight. No correction is made for the waste.

After two samplings at each city it was found that the calcium content of most food categories did not vary among cities, nor did it vary significantly with time. Calcium analyses of dietary components were performed for the third time recently, and further confirmed this result (*2*). Calcium analyses were therefore discontinued and average calcium content of foods was computed and used to estimate the average annual intake of this mineral. Details of the sampling system and a discussion of the results obtained have been summarized (*3*).

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[1] Data from *Fallout Program Quarterly Summary Report, HASL–155*:208–10, Office of Technical Services, Department of Commerce, Washington, D. C. 20230 (January 1, 1965) price $4.00.

TABLE 1.—AVERAGE PER PERSON DIETARY CONSUMPTION AND STRONTIUM-90 INTAKE, AUGUST-OCTOBER 1964 SAMPLING

Food category	Average U.S. consumption		Strontium-90 intake					
			New York City, August 1964		Chicago, October 1964		San Francisco, September 1964	
	Diet (kg/yr)	Calcium (g/yr)	pCi/kg ᵃ	pCi/yr	pCi/kg ᵃ	pCi/yr	pCi/kg ᵃ	pCi/yr
Bakery products	37	37.0	28.4±1.2	767	25.3±1.2	936	17.9±0.9	662
Whole grain products	11	10.0	96.1±2.3	1057	39.5±1.4	434	49.0±1.5	539
Eggs	16	9.1	6.5±0.1	104	9.4±0.2	150	6.0±0.1	96
Fresh vegetables	43	15.0	19.9±0.4	856	16.2±0.6	697	3.1±0.2	133
Root vegetables	17	6.1	8.2±0.2	139	13.6±0.4	231	5.9±0.3	100
Milk	221	234.3	24.0	5304	12.0±0.4	2652	4.8±0.4	1061
Poultry	17	9.2	3.7±0.1	63	2.6±0.4	44	3.4±0.1	58
Fresh fish	8	10.8	1.6±0.1	13	2.9±0.2	23	0.7±0.1	6
Flour	43	8.6	20.8±0.4	894	26.9±0.5	1157	10.8±0.2	464
Macaroni	3	0.7	15.0±0.4	45	20.1±0.5	60	11.3±0.3	34
Rice	3	1.1	5.4±0.2	16	6.0±0.2	18	3.2±0.2	9
Meat	73	10.9	2.0±0.1	146	1.6±0.2	117	2.2±0.1	161
Shellfish	1	0.8	1.8±0.1	2	0.8±0.1	1	1.3±0.2	1
Dried beans	3	2.9	30.3±1.8	91	34.9±2.3	105	21.3±1.5	64
Fresh fruit	68	12.6	11.3±0.4	768	3.3±0.2	224	2.0±0.2	136
Potatoes	45	5.8	9.9±0.4	446	13.4±0.6	603	1.3±1.6	58
Canned fruit	26	1.3	3.0±0.2	78	4.7±0.2	122	1.7±0.1	44
Fruit juices	19	1.7	2.1±0.2	40	4.8±0.3	91	4.5±0.2	86
Canned vegetables	20	4.2	22.8±0.7	456	18.6±0.8	372	2.4±0.3	48
Annual intake	674	383.		11285		7937		3760
pCi ^{90}Sr/g Ca in total diet			29.5		20.7		9.8	

ᵃ Error terms are one standard deviation (due to counting).

Results of the August-October 1964 sampling are presented in table 1. The variation with time of the daily intake of strontium-90 in the three cities is plotted in figure 1.

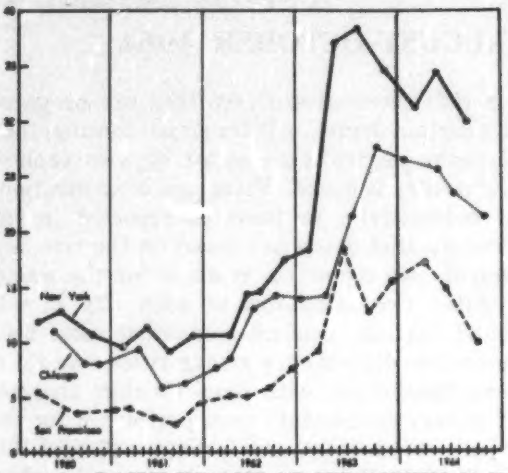

FIGURE 1.—DAILY INTAKE OF STRONTIUM-90 IN TRI-CITY TOTAL DIETS

In New York the strontium-90 intake is observed to decrease with respect to the previous samplings three months earlier. The San Francisco and Chicago strontium-90 intakes are observed to decrease as they have over the previous two sampling periods. This trend can be expected to continue with the discontinuation of atmospheric nuclear testing.

Discussion

The previously noted geographic distribution pattern of strontium-90 in the diet is seen to persist as it has since the initial samplings in 1960. Levels have been highest in New York City and lowest in San Francisco. Due in part to its high annual consumption, milk continues to be the predominant source of strontium-90 in diet.

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(*1*) U. S. DEPARTMENT OF AGRICULTURE. Food consumption of households in the United States, Report No. 1, 1955. Household Food Consumption Survey, Superintendent of Documents, Government Printing Office, Washington, D. C. 20402 (December 1956), price $1.00.

(*2*) U. S. ATOMIC ENERGY COMMISSION. Fallout program quarterly summary report. HASL-144:281-287, Office of Technical Services, Department of Commerce, Washington, D. C. 20230 (April 1, 1964), price $4.00. Summarized in Rad Health Data 5: 285-288 (June 1964).

(*3*) RIVERA, J. and J. H. HARLEY. HASL contributions to the study of fallout in food chains. HASL-147, Office of Technical Services, Department of Commerce, Washington, D. C. 20230 (July 1, 1964), price $1.50.

Recent coverage in *Radiological Health Data:*

Period	Issue
Thirteenth sampling (May-July 1963)	*March 1964*
Fourteenth sampling (August-October 1963)	*June 1964*
Fifteenth sampling (November 1963-January 1964)	*September 1964*
Sixteenth Sampling (February 1964-April 1964)	*December 1964*
Seventeenth Sampling (July-September 1964)	*March 1965*

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Section III—Water

GROSS RADIOACTIVITY IN SURFACE WATERS OF THE UNITED STATES, DECEMBER 1964

Division of Water Supply and Pollution Control, Public Health Service

Levels of radioactivity in surface waters of the United States have been monitored by the Public Health Service Water Pollution Surveillance System since its initiation in 1957. Beginning with the establishment of 50 sampling points, this system has been expanded to 131 stations as of May 1, 1965. These are operated jointly with other Federal, State, and local agencies, and industry. Samples are taken from surface waters of all major U.S. river basins for physical, chemical, biological, and radiological analyses. These data can be used for evaluating sources of radioactivity which may affect specific domestic, commercial, and recreational uses of surface water. Further, the system provides background information necessary for recognizing pollution and water quality trends and for determining current and general levels of radioactivity to which the population may be exposed. Data assembled through the system and exact locations of sampling points are published in annual compilations (*1–6*).

Sampling procedures

The participating agencies collect one-liter "grab" samples each week and ship them "as is" to the Surveillance System Laboratory in Cincinnati for analysis. Gross alpha and gross beta radioactivity determinations on the suspended and dissolved solids are performed as frequently as deemed necessary.

Presently, gross alpha and beta determinations are made either on monthly composites of the weekly samples or on each weekly sample. Weekly alpha and beta determinations are scheduled for stations located downstream from known potential sources of radioactive waste. Weekly analyses are conducted at all newly established stations for the first year of operation. Weekly analyses are also scheduled for selected stations in an effort to detect short term radioactivity effects from current or recent nuclear tests or events.

Normally samples are counted within two weeks following collection or within one week after compositing. The decay of activity is followed on each sample for which the first analysis shows unusually high activity. Also, if a recount indicates that the original analysis was questionable, values based on recounting are recorded. All results are reported for the time of counting and are not extrapolated to the time of collection.

Strontium–90 analyses are performed on total solids of three-month composite of the weekly samples. The most recent strontium–90 results are presented in the March 1965 *RHD*.

Analytical methods

The analytical method used for determining gross alpha and beta radioactivity is described in the eleventh edition of "Standard Methods

for the Examination of Water and Wastewater" (*7*). Suspended and dissolved solids are separated by passing the sample through a membrane filter (type HA) with a pore size of 0.45 micron. Planchets are then prepared for counting the dissolved solids (in the filtrate) and the suspended solids (on the charred membrane filter) in an internal proportional counter. Reference sources of U_3O_8, which give a known count rate if the instrument is performing properly, are used for daily checking of the counter.

Results

Table 1 presents December 1964 results of alpha and beta analyses of U.S. surface waters. The stations on a river are arranged in the table according to their relative location on the river, the first stations listed being closest to the headwaters. These data are preliminary. The figures for gross alpha and gross beta radioactivity represent either determinations on composite samples or means of weekly determinations where composites were not made. The monthly means are reported to the nearest pCi/liter. When all samples have zero pCi/liter, the mean is reported as zero; when the calculated mean is between zero and 0.5 the mean is reported as <1 pCi/liter.

A geographical perspective of the radioactivity in surface water is obtained from the numbers printed near the stations as shown in figure 1 which gives the average total beta activity in suspended-plus-dissolved solids in raw water collected at each station. Gross radioactivity results for the year 1957–1962 have been summarized by Weaver *et al* (*8*).

The radioactivity associated with dissolved solids provides a rough indication of the levels which could occur in treated water, since nearly all suspended matter is removed by the treatment process (*9*). The Public Health Service Drinking Water Standards state that in the

TABLE 1.—RADIOACTIVITY IN RAW SURFACE WATERS, DECEMBER 1964[a]

Station	Beta activity, pCi/liter			Alpha activity, pCi/liter		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Animas River:						
Cedar Hill, N. Mex	21	16	37	5	1	6
Arkansas River:						
Coolidge, Kans	5	52	57	1	26	27
Ponca City, Okla	9	7	16	3	4	7
Atchafalaya River:						
Morgan City, La	86	13	99	26	1	27
Bear River:						
Preston, Idaho	1	15	16	0	0	0
Big Horn River:						
Hardin, Mont	2	13	15	1	8	9
Chena River:						
Fairbanks, Alaska	2	1	3	0	0	0
Clinch River:						
Clinton, Tenn	2	8	10	0	0	0
Kingston, Tenn	2	39	41	0	<1	<1
Colorado River:						
Loma, Colo	0	29	29	0	2	2
Page, Ariz	1	32	33	0	7	7
Parker Dam, Calif-Ariz	1	16	17	0	3	3
Columbia River:						
Wenatchee, Wash	1	9	10	0	1	1
Pasco, Wash	42	801	843	0	1	1
Clatskanie, Ore	31	38	69	2	0	2
Connecticut River:[b]						
Enfield Dam, Conn	2	9	11	1	0	1
Coosa River:						
Rome, Ga	5	6	11	0	0	0
Cumberland River:						
Cheatham Lock, Tenn	2	9	11	1	0	1
Delaware River:						
Philadelphia, Pa	2	5	7	1	0	1
Great Lakes:						
Duluth, Minn	0	3	3	0	0	0
Hudson River:						
Poughkeepsie, N.Y	8	20	28	1	1	2
Kansas River:						
De Soto, Kans	2	30	32	0	3	3
Maumee River:						
Toledo, Ohio	6	20	26	1	0	1
Mississippi River:						
St. Paul, Minn	4	20	24	0	2	2
E. St. Louis, Ill	5	18	23	1	1	2
New Roads, La	11	11	22	6	1	7
New Orleans, La	14	11	25	3	0	3
Missouri River:						
Williston, N. Dak	9	18	27	5	5	10
St. Joseph, Mo	6	33	39	0	5	5
North Platte River:						
Henry, Nebr	6	34	40	0	27	27
Ohio River:						
Cairo, Ill	8	8	16	7	0	7
Toronto, Ohio	2	9	11	0	0	0
Platte River:						
Plattsmouth, Nebr	8	24	32	1	5	6
Potomac River:						
Washington, D.C	3	7	10	1	0	1
Red River, North:						
Grand Forks, N. Dak	2	39	41	0	1	1
Red River, South:						
Alexandria, La	10	8	18	4	0	4
Rio Grande:						
El Paso, Tex	12	43	55	1	2	3
Laredo, Tex	2	13	15	0	3	3
San Joaquin River:						
Vernalis, Calif	2	3	5	0	1	1
San Juan River:						
Shiprock, N. Mex	24	34	58	5	12	17
Savannah River:						
Port Wentworth, Ga	3	8	11	0	0	0
Snake River:						
Wawawai, Wash	3	12	15	0	2	2
South Platte River:						
Julesburg, Colo	23	60	83	5	33	38
Tennessee River:						
Chattanooga, Tenn	1	9	10	<1	0	<1
Wabash River:						
New Harmony, Ind	3	13	16	0	0	0
Yellowstone River:						
Sidney, Mont	0	16	16	1	5	6
Maximum	86	801	843	26	33	38
Minimum	0	1	3	0	0	0

[a] These data are preliminary: reanalysis of some samples may be made and additional analysis not completed at the time of the report may become available. For final data, one should consult the system's annual report.

[b] Because of the nature of the nuclides present in the Columbia River below the Pacific Northwest Laboratory (Hanford Plant), gross beta activity at this station is not directly comparable to gross beta activity at other stations.

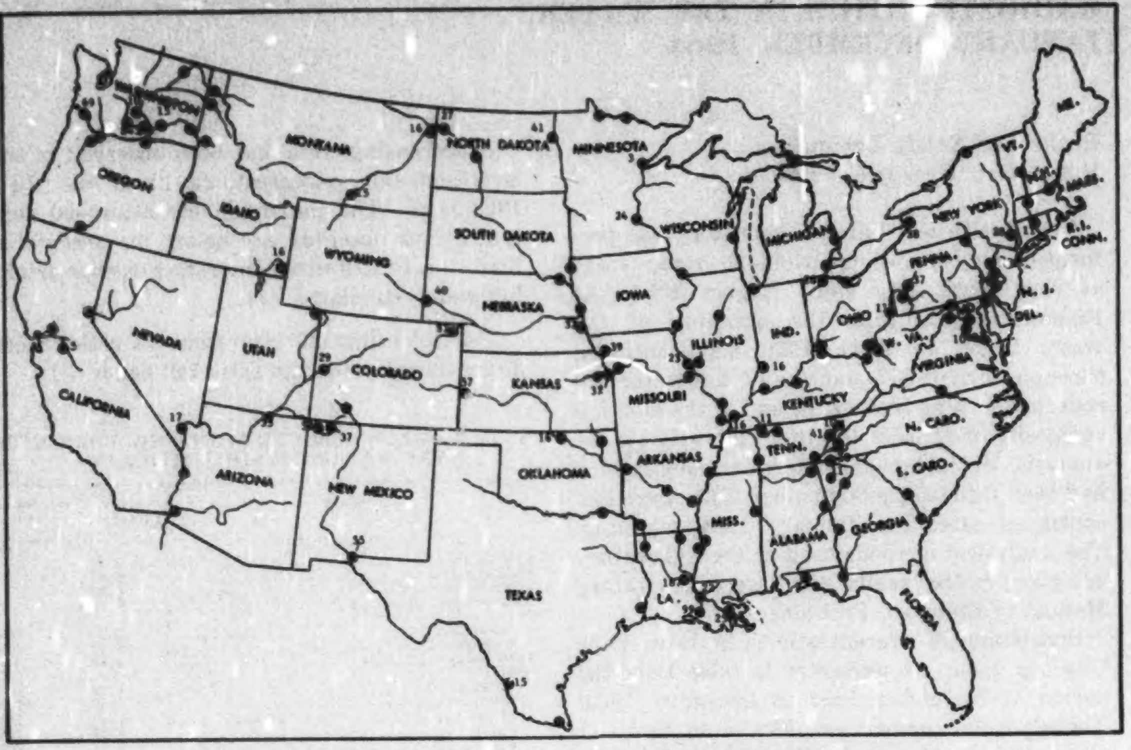
WASHINGTON
OREGON
CALIFORNIA
NEVADA
IDAHO
MONTANA
WYOMING
UTAH
ARIZONA
COLORADO
NEW MEXICO
NORTH DAKOTA
SOUTH DAKOTA
NEBRASKA
KANSAS
OKLAHOMA
TEXAS
MINNESOTA
IOWA
MISSOURI
ARKANSAS
LA.
WISCONSIN
ILLINOIS
MISS.
MICHIGAN
IND.
KENTUCKY
TENN.
ALABAMA
OHIO
W. VA.
VIRGINIA
N. CARO.
S. CARO.
GEORGIA
FLORIDA
PENNA.
NEW YORK
VT.
N.H.
ME.
MASS.
CONN.
R.I.
N. J.
DEL.

FIGURE 1.—SAMPLING LOCATIONS AND ASSOCIATED TOTAL BETA ACTIVITY (pCi/liter) IN SURFACE WATERS, DECEMBER 1964

absence of strontium-90 and alpha emitters,[1] a water supply is acceptable when the gross beta concentration does not exceed 1,000 pCi/liter (*10*).

During December 1964, the highest reported level was at Pasco, Washington, where the average monthly total gross beta activity concentration was 843 pCi/liter. However, because of the nature of the radionuclides present in the Columbia River below Hanford, it is important to note that this value is not directly comparable to gross beta activity at other stations.

REFERENCES

(*1*) DIVISION OF WATER SUPPLY AND POLLUTION CONTROL, PUBLIC HEALTH SERVICE. National water quality network annual compilation of data. PHS Publication No. 663, 1958 Edition, Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20402. Price $1.50.

(*2*) *Ibid.*, 1959 Edition. Price $1.75.

(*3*) *Ibid.*, 1960 Edition.[2]

(*4*) *Ibid.*, 1961 Edition.[2]

(*5*) *Ibid.*, 1962 Edition.[2]

(*6*) DIVISION OF WATER SUPPLY AND POLLUTION CONTROL, PUBLIC HEALTH SERVICE. Water pollution surveillance system annual compilation of data. PHS Publication No. 663 (Revised) 1963 ed., Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

(*7*) AMERICAN PUBLIC HEALTH ASSOCIATION; AMERICAN WATER WORKS ASSOCIATION AND WATER POLLUTION CONTROL FEDERATION. Standard methods for the examination of water and wastewater. 11th Edition, New York (1960).

(*8*) WEAVER, L., A. W. HOADLEY, and S. BAKER. Radioactivity in surface waters of the United States, 1957–1962. Rad Health Data 4: 306–16 (June 1963).

(*9*) STRAUB, C. P. Significance of radioactivity data. JAWWA 53:704 (June 1961).

(*10*) PUBLIC HEALTH SERVICE. Drinking water standards, revised 1962. Public Health Service Publication No. 956, Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20402 (March 1963), Price 30 cents.

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[1] Absence is taken here to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha emitters and strontium-90, respectively.

[2] Single free copies of this publication may be obtained from: Public Inquiries Branch, Public Health Service, U. S. Department of Health, Education, and Welfare, Washington, D. C. 20201.

RADIOSTRONTIUM IN TAP WATER,[1] JANUARY-DECEMBER 1964

Health and Safety Laboratory
U.S. Atomic Energy Commission

The Health and Safety Laboratory has performed analyses for strontium-90 in tap water at New York City since August 1954. At Richmond, California, the sampling of tap water began in April 1958 and continued through June 1963. Samples of tap water are collected daily so that by the end of the month a composite of at least 100 liters is available for analysis. Strontium-89 determinations, which had been made since September 1961, were discontinued after the January 1964 sampling. The analytical methods used at the Laboratory are given in the Health and Safety Laboratory Manual of Standard Procedures (*1*).

Strontium-90 concentrations in New York City tap water are presented in table 1 for the period of November 1963 to December 1964. These results appear graphically in figure 1 along with Richmond, California, results since 1958. Data prior to 1958 appear in an earlier HASL report (*2*).

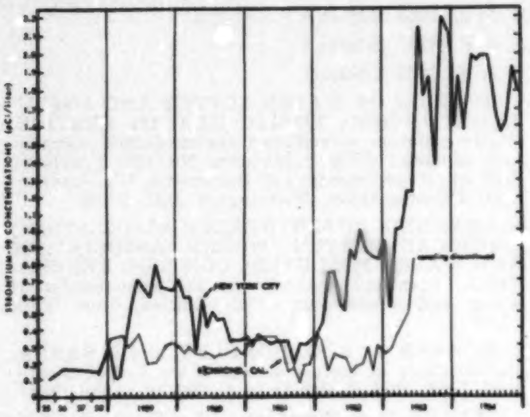

FIGURE 1.—STRONTIUM-90 CONCENTRATIONS IN TAP WATER

Recent coverage in *Radiological Health Data:*

Period	Issue
March–June 1962	*January 1963*
July–December 1962	*July 1963*
January–April 1963	*January 1964*
May–October 1963	*April 1964*

A decreasing trend has been observed in the strontium-90 concentrations since the July 1963 peak. The maximum strontium-90 concentrations observed are below the acceptable limit as set forth in the interstate carrier drinking water standards (*3*).

The strontium-89/strontium-90 ratios were discontinued when the ratio fell below 0.1.

TABLE 1.—RADIOSTRONTIUM IN NEW YORK CITY TAP WATER, 1959–DECEMBER 1964

Period	^{90}Sr [a] (pCi/liter)	^{89}Sr/^{90}Sr [b]
1959 average	0.40	
1960 average	0.47	
1961 average	0.32	
1962 average	0.72	
1963		
November	2.20	0.4
December	2.02	0.4
1963 average	1.45	
1964		
January	1.62	<0.1
February	1.86	[c] NA
March	1.59	NA
April	1.98	NA
May	1.96	NA
June	1.98	NA
July	1.98	NA
August	1.68	NA
September	1.54	NA
October	1.61	NA
November	1.92	NA
December	1.80	NA
1964 average	1.79	

[a] From 100–200 liters per sample.
[b] Strontium-89 extrapolated to midpoint of sampling period. Strontium-89 analyses discontinued after January 1964.
[c] NA indicates no analysis performed (see text).

REFERENCES

(*1*) U.S. ATOMIC ENERGY COMMISSION. Manual of standard procedures. 40:E-38-01-16. Health & Safety Laboratory, U.S. Atomic Energy Commission, 376 Hudson St., New York 14, N.Y.

(*2*) U.S. ATOMIC ENERGY COMMISSION. Environmental contamination from weapons tests. HASL-42, Office of Technical Services, Department of Commerce, Washington, D.C. 20230 (October 1962).

(*3*) PUBLIC HEALTH SERVICE, DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE. Federal register rules and regulations. Title 42, Public Health, Chapter 1, Part 72: Interstate quarantine, Subpart J, Drinking Water Standards. 27:2154-2155. Superintendent of Documents, Government Printing Office, Washington, D.C. 20402 (March 6, 1962).

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[1] Data taken from AEC Fallout Program Quarterly Sumary Report, HASL-155: 199-207, Office of Technical Services, U.S. Department of Commerce, Washington, D.C. 20230 (January 1, 1965).

Section IV—Other Data

ENVIRONMENTAL LEVELS OF RADIOACTIVITY AT ATOMIC ENERGY COMMISSION INSTALLATIONS

The U.S. Atomic Energy Commission receives from its contractors semi-annual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant perimeter surveys are required.

Summaries of the environmental radioactivity data for 22 AEC installations have appeared periodically in *RHD* since November 1960. Summaries follow for Brookhaven National Laboratory and Rocky Flats Plant.

Releases of radioactive materials from these installations for the periods covered in the reports below are governed by standards set forth in appropriate chapters of the AEC manual. The radioactivity concentration limits applicable to effluents released from AEC installations are essentially those published in the Federal Register (*1*)

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1. Brookhaven National Laboratory
July–December 1964

Associated Universities, Inc.
Upton, New York

The Brookhaven National Laboratory (BNL) operations may affect the environmental levels of radiation in three ways: (1) by discharge of coolant air from the graphite research reactor, (2) by radiation from an ecology forest gamma source, and (3) by the discharge of low-level radioactive liquid wastes into a small stream that forms one of the headwaters of the Peconic River (figure 1).

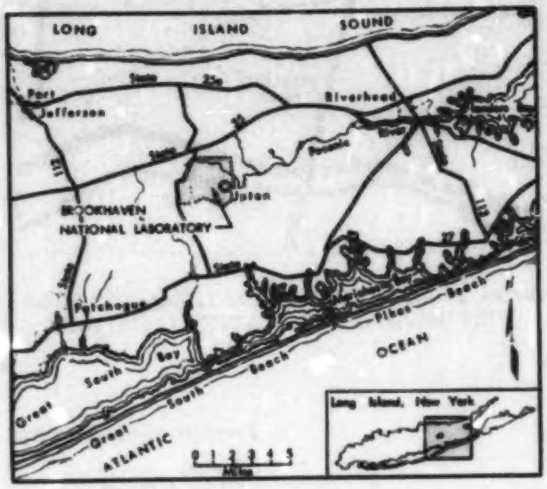
LONG
ISLAND
SOUND
Port
Jefferson
State
25a
25
Riverhead
Peconic
River
State
111
Upton
BROOKHAVEN
NATIONAL LABORATORY
State
Patchogue
27
Great
South
Bay
Great
South
Beach
Pikes
Beach
OCEAN
ATLANTIC
N
0 1 2 3 4 5
Miles
Long Island, New York

FIGURE 1.—BROOKHAVEN NATIONAL LABORATORY AND SURROUNDING AREA

Area monitoring

The radioactivity in the discharge coolant air is almost entirely due to argon–41, a beta-gamma emitter. Because exposure to argon–41 is due to external gamma, the monitoring is performed by measuring the exposure rate in milliroentgens per week (mR/wk) rather than the concentration in air.

Late in 1961 a 10,000-curie cesium–137 gamma source was installed in the ecology forest about 800 meters equidistant from the north and east boundaries (*2*).

Table 1 presents the average external gamma exposure rates measured at the four stations shown in figure 2. The higher levels at the Northeast perimeter station are primarily due to the ecology forest source. The environmental maximum permissible dose recommended by the Federal Radiation Council is 0.5 rem/yr (10 mrem/wk) above the natural background, averaged over a one-year period.

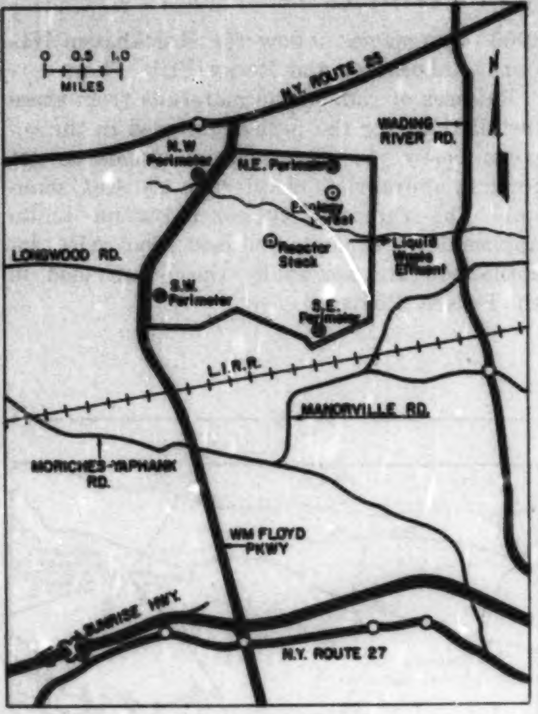
0
0.5
1.0
MILES
N.Y. ROUTE 25
N
WADING RIVER RD.
N.W Perimeter
N.E. Perimeter
Ecology Forest
Reactor Stack
Liquid Waste Effluent
LONGWOOD RD.
S.W. Perimeter
S.E. Perimeter
L.I.R.R.
MANORVILLE RD.
MORICHES-YAPHANK RD.
WM FLOYD PKWY
SUNRISE HWY.
N.Y. ROUTE 27

FIGURE 2.—BROOKHAVEN NATIONAL LABORATORY MONITORING STATION LOCATIONS

TABLE 1.—EXTERNAL GAMMA LEVELS AT BNL SITE BOUNDARY

(Average exposure rates in mR/wk)

Period	Northwest perimeter [a]	Southwest perimeter	Southeast perimeter	Northeast perimeter
Gamma exposure from laboratory operations:				
First half 1964	0.25	0.43	0.52	2.33
Second half 1964				
July	0.08	0.22	0.41	4.24
August	0.10	0.38	0.37	3.51
September	0.08	0.61	0.11	2.70
October	0.09	0.16	0.70	2.38
November	0.30	0.20	0.36	3.02
December	0.05	0.10	0.41	1.81
Second half 1964	0.12	0.30	0.39	2.82
Undisturbed background:				
First half 1964	2.78	2.90	3.12	3.28
Second half 1964	2.69	2.78	3.17	3.07

[a] Northwest perimeter station is located 680 meters inside boundary, and is designated "N. Gate" in figure 2. The others are on the boundary.

Water monitoring

The BNL liquid waste effluent is monitored for gross beta concentrations at the site boundary. Table 2 presents the average concentration together with the total activity released as determined by using known effluent flow rates.

TABLE 2.—GROSS BETA ACTIVITY IN BNL LIQUID WASTE EFFLUENT, JANUARY-DECEMBER 1964

Period	Average beta concentration (pCi/liter)	Total beta activity discharged (mCi)
First half 1964	75	42.4
Second half 1964		
July	82	6.9
August	72	6.8
September	60	5.7
October	71	5.9
November	59	4.1
December	54	4.6
Second half 1964	66	34.0

Previous coverage in *Radiological Health Data:*

Period	Issue
Third & fourth quarters 1961	*June 1962*
First & second quarters 1962	*January 1963*
July 1962 to June 1963	*February 1964*
July 1963 to June 1964	*December 1964*

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2. Rocky Flats Plant
July–December 1964

Dow Chemical Company
Golden, Colorado

The Rocky Flats Plant (RFP) is engaged in routine production operations involving plutonium and uranium under contract to the Atomic Energy Commission. Its location relative to population centers is shown in figure 3. To assure properly controlled release of radioactive materials to the environment, periodic samples of water, air, and vegetation are analyzed for gross alpha activity. The most abundant radioactive material involved in the process is plutonium.

The plant is located about 15 miles northwest of Denver. The surface stratum in this area consists of gravel washed out of the highly mineralized Front Range of the Rocky Mountains, where heterogeneous low-level deposits of uranium, thorium, and radium exist in the soil. These materials are measurable in most samples of air, water, and vegetation.

Air

Continuous 24-hour air samples were collected at Coal Creek Canyon, Marshall, Boulder, Lafayette, Broomfield, Wagner School, Golden, Denver, and Westminster. The monthly average long-lived gross alpha activities are shown in table 3. The alpha activity is believed to result entirely from naturally occurring materials.

TABLE 3.—LONG-LIVED ALPHA ACTIVITY IN PARTICULATES IN AIR, RFP

Period	Average alpha concentration (pCi/m^3)
1964	
July	0.006
August	0.012
September	0.009
October	0.019
November	0.007
December	0.008
July—December 1964	0.010

Water monitoring

Semi-monthly water samples were collected from four reservoirs at distances ranging from 3 to 8 miles from RFP. The average alpha concentrations in the four reservoirs during the second half of 1964 are shown in table 4.

TABLE 4.—ALPHA ACTIVITY IN WATER COLLECTED FROM RESERVOIRS IN THE VICINITY OF RFP

[Average concentrations in pCi/liter]

Reservoir	Second half 1964	1964
Great Western	2.0	2.3
Standley	2.7	2.7
Baseline	1.6	1.4
Ralston	1.0	2.3

Non-routine raw surface water samples were collected from a number of outlying streams and lakes along with the vegetation samples. The 35 samples collected during the second half of 1964 had an average gross alpha activity of 2.5 pCi/liter.

Vegetation Samples

A total of 116 vegetation samples were analyzed during 1964. The average gross alpha activities of these samples was 120 pCi/kg dry for samples collected within 3 miles of the plant, and 135 pCi/kg dry for those collected 3 to 18 miles from RFP.

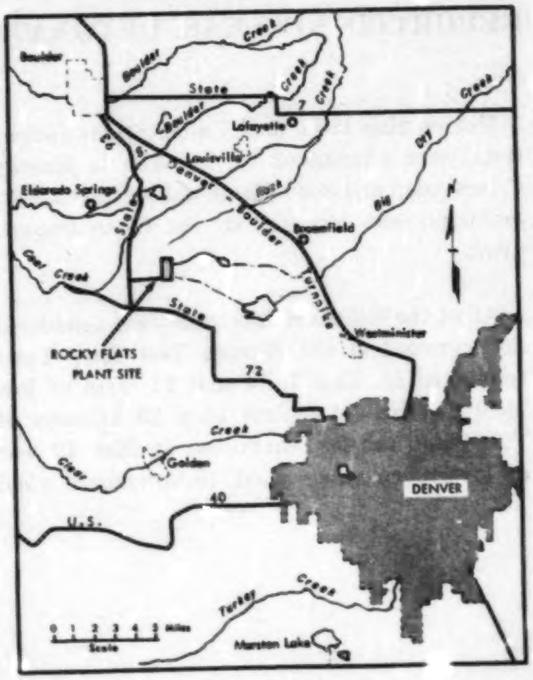
Boulder
Boulder Creek
State
Creek
7
Creek
Boulder
Lafayette
Louisville
Eldorado Springs
State
Denver
Boulder
Turnpike
Rock
Broomfield
Big Dry Creek
N
Clear Creek
State
Westminster
ROCKY FLATS
PLANT SITE
72
Creek
Clear
Golden
DENVER
40
U.S.
Turkey Creek
0 1 2 3 4 5 miles
Scale
Marston Lake

FIGURE 3.—LOCATION OF THE ROCKY FLATS PLANT ENVIRONMENT, DENVER, COLORADO

REFERENCES

(*1*) U.S. ATOMIC ENERGY COMMISSION. Rules and regulations, standards for protection against radiation. Title 10, CFR 20, Government Printing Office, Washington, D.C. 20402.

(*2*) HULL, A. P. 1962 environmental radiation levels at Brookhaven National Laboratory, BNL 807 (T-310) Health and Safety—TID—4500, 21st ed.) (May 1963). Office of Technical Services, Department of Commerce, Washington, D.C. 20430.

Recent coverage in *Radiological Health Data:*

Period	Issue
Second half 1961	*May 1962*
First half 1962	*January 1963*
July 1962–June 1963	*February 1964*
July 1963–June 1964	*December 1964*

REPORTED NUCLEAR DETONATIONS, MAY 1965

During May 1965, four United States nuclear tests were announced by the Atomic Energy Commission and one nuclear test on the Chinese mainland was reported by the State Department.

All of the United States tests were conducted underground at the Nevada Test Site. Tests conducted on May 7, 14 and 21 were of low yield (equivalent to less than 20 kilotons of TNT) and the test conducted on May 12 was of low-intermediate yield (intermediate yield is defined as equivalent to 20 to 200 kilotons of TNT).

The mainland Chinese test was announced to have occurred at 0200 Greenwich time, May 14, 1965. Early information indicated that the test was conducted in the atmosphere, involved a fission device using uranium–235, and was of somewhat higher yield than the Chinese detonation of October 16, 1964. Public Health Service field estimates and laboratory analyses of air samples confirmed the presence of fresh fission products consistent with the timing of the detonation.